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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

DECEMBER 1924

SOCIETY OF AUTOMOTIVE ENGINEERS INC.
29 WEST 39TH STREET NEW YORK

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. XV December, 1924 No. 6

Chronicle and Comment

The Annual Dinner

NO member who can possibly attend should miss the 1925 Annual Dinner of the Society, which will be held at the Hotel Astor, New York City, on the evening of Thursday, Jan. 8. Order-blanks for tickets will be mailed to the members about the middle of this month.

Joint Collection of Society and Section Dues

ATTENTION was called last month to the apparent great success of the new method of collecting the annual dues of the Sections with those of the National Society. Up to Nov. 25, nearly 1500 Society members had paid Section dues for the current fiscal year. The total number who paid Section dues for the last fiscal year was 1148. About half of those who have paid Section dues for this year were not Section members last year.

1925 Annual Meeting

THE professional sessions and the adjourned business-session of the 1925 Annual Meeting of the Society will be held in Detroit, Jan. 19 to 22. The business-session of the meeting will be called to order at the Annual Dinner to be held in New York City, on Jan. 8, for the purpose of announcing the results of the election of the Officers and Councilors of the coming administration.

The Carnival, the social event of the meeting, will be held at Oriole Terrace, Detroit, on the evening of Jan. 21.

New Jersey Motorcoach Regulations

AT the final hearing of the New Jersey Board of Public Utility Commissioners held in Trenton, on Nov. 25, A. J. Scaife, representing the Society's Motorcoach Committee, presented several of the recommendations approved by the Committee and given on p. 492 of this issue, as being preferable to certain of the regulations drawn up by the traffic supervisors of the principal municipalities of New Jersey. D. C. Fenner, a member of the Motorcoach Committee and of the Motor-Vehicle Conference Committee, was also present.

As a result of the discussion at the meeting of the Motorcoach Committee, held on Nov. 7, at which representatives of the American Electric Railway Association and several of the New Jersey traffic supervisors were present, a number of the recommendations of the Committee had been incorporated in the regulations proposed at the hearing by the traffic supervisors.

Although the Board will not issue its findings immediately, it is believed that most of the recommendations of the Motorcoach Committee were received favorably by the Board. Owing to local conditions, however, it is probable that the New Jersey regulations will specify the maximum body-length of 21 instead of 24 ft., and the minimum inside-height of 6 ft. 4 in. instead of 6 ft. 2 in., for the city type of motorcoach.

American Petroleum Institute Meeting

THE fifth annual meeting of the American Petroleum Institute will be held at Fort Worth, Tex., on the 9th, 10th and 11th of this month. Members of the Society will be welcome at this meeting. The session in which they will be interested particularly is that scheduled for the afternoon of Dec. 11. At this a report on the current motor-fuel investigation will be made by H. K. Griffin, of the Bureau of Standards. He will also discuss a new method for determining crankcase-oil dilution. In addition, the following subjects will be discussed: Lubrication of the Automobile Engine and Utilization of Motor Fuel from the Standpoint of the Automotive Engineer.

Conference on Street and Highway Safety

SECRETARY HOOVER, of the Department of Commerce, feels that the committee reports which will be considered when the Conference on Street and Highway Safety convenes in the City of Washington on the 15th of this month are comprehensive and constructive in character and therefore entitled to most careful consideration by the general public as well as by the Conference. The eight committees, which have been at work for many months, have studied the large number of problems involved in highway safety, the general subjects considered being statistics, traffic control, construction and engineering, city planning and zoning, insurance, education, the motor vehicle and public relations. The reports of the committees have been printed in separate pamphlet form.

President Crane is chairman of the Motor Vehicle

Committee. Other members of the Society who served on this committee are: C. R. Alling, A. B. Cumner, H. C. Dickinson, H. L. Horning, E. E. LaSchum, L. H. Palmer, T. D. Pratt and Clayton H. Sharp. In addition to general matters, the reports contain recommendations on the following elements of motor-vehicle construction and operation from the standpoint of safety: controls, brakes and braking, steering-gears and steering, driver vision, lights, signals, anti-skid and traction devices, tires, bumpers, bodies, loading, anti-theft locks, speed governors and inspection.

Pan-American Conference on Standardization

KIRKE K. HOAGG will represent the Society at the Conference on Standardization scheduled to convene at Lima, Peru, on the 23rd of this month. It is understood that, in addition to a large number of representatives from engineering, scientific and industrial organizations, delegates from more than 20 republics that participate in the activities of the Pan-American Union will be present.

The general purpose of the conference is to develop in due course international standards for raw and finished materials, as well as standard classifications and nomenclature. It is stated that Latin America is the largest continental market in the world for automotive products of the United States.

1925 Summer Meeting

THE coming Summer Meeting of the Society will be held at White Sulphur Springs, W. Va. The Greenbrier Hotel and cottages controlled by it will be available for the accommodation of the members.

The 1922 Summer Meeting was held at White Sulphur. It is generally agreed that, for a place of the kind, nothing is superior to this resort. Its accommodations and cuisine are of the highest order and the general surroundings are of a delightful nature.

The dates set for the coming meeting are June 16 to 19.

It was the intention of the Meetings Committee and the Council to select a place in the Middle West at which to hold the coming meeting, but after a thorough investigation it was found impossible to secure there adequate accommodations of a suitable nature.

Tilting Preferable to Dimming

THE tests recently made by the Motor-Vehicle Lighting Committee of the Illuminating Engineering Society, reported in full on p. 494 of this issue, indicate that it is preferable to tilt instead of to dim the headlights. Although headlights adjusted in accordance with the present S.A.E. Specifications, which are now legal in practically every Eastern State, suffice for ordinary driving, it is argued that instances occur not infrequently in which it is necessary for safe operation to tilt or dim the headlights.

Dimming, however, is illegal in Massachusetts. There is no question that, if headlights are dimmed and the vehicle's speed maintained, accidents will occur owing to inadequate visibility. The result of the tests made by the Illuminating Engineering Society Committee seemed to indicate that tilting of headlights may be the final solution of this problem.

Dopes for Gasoline

GREAT interest is attached at the present time to the subject of fuel dopes and it is believed worthwhile to present in these columns a brief authoritative summary of the situation as it is viewed by a laboratory having at its disposal suitable equipment and personnel qualified to establish the pertinent facts involved.

The Bureau of Standards has conducted extensive tests of dopes and doped fuels that are supposed to improve the performance of internal-combustion engines. None of the tests made at the Bureau thus far has shown that the use of these dopes produced any appreciable improvement in power or fuel consumption, provided no detonation was present when using the untreated gasoline.

Such dopes as are beneficial derive their value from their influence upon detonation. Detonation is that phenomenon whose most familiar manifestation is the sharp ringing sound heard when an engine is badly carbonized or is operating with an over-advanced spark. Its consequences frequently are a loss in power, an increase in the specific fuel-consumption and a tendency for the engine to overheat. Retarding the spark abnormally to avoid detonation may produce the same results. These consequences may be partially or completely prevented by the use of a dope that will decrease the tendency of the fuel to detonate. Insofar as the experience of the Bureau is concerned, this is the only manner in which a dope has been found to produce any appreciable improvement in either the power or the specific fuel-consumption.

An accumulation of carbon in an internal-combustion engine usually increases the tendency of the engine to detonate. Because a dope decreases the detonation, it is often supposed that it removes carbon. As yet, the Bureau is not in the possession of convincing evidence that the use of any fuel-dope has a pronounced influence upon the rate of carbon formation. This is by no means positive proof that no such influence exists. The obtaining of definite information on such a question usually requires a rather extensive series of tests. The reason in this case lies in the difficulty of controlling or evaluating the influence of factors other than the quality of the fuel upon the rate of carbon formation.

An improvement in fuel economy often accompanies the use of a fuel dope that actual tests show to be worthless. The gain results from adjusting the carbureter to give a leaner mixture when using the dope. The user in such cases is led to believe that the dope made better economy possible, whereas, with the lean mixture, the results would have been the same with the untreated fuel.

On p. 499 of this issue will be found an interesting discussion of the effect of running the engine in eliminating carbon.

MEETINGS OF THE SOCIETY

THE SERVICE MEETING

THE QUESTION OF SERVICE

Alvan Macauley Gives Historical Outline and Definition of the Problem

In his capacity as chairman of the Service Committee of the National Automobile Chamber of Commerce, Alvan Macauley, president of the Packard Motor Car Co., called to order on the morning of Nov. 18 the Joint Service Meeting of the National Automobile Chamber of Commerce and the Society, at the Hotel Winton, Cleveland.

Mr. Macauley said, in part:

The question of service, of vehicle maintenance, has long been the bugbear of our industry. It is a problem that has been with us since the day the first car and the first truck were made and sold.

In the early days of the industry, before transportation was merchandised, when the automobile was sold as a plaything, someone started the saying, "It isn't the first cost, it's the upkeep." In those days it was very likely to be true that a prospective customer, well able to afford the then relatively high purchase-price of a motor car, could not afford the continuing annual outlay required to keep the vehicle in operation. The yearly cost of maintenance was apt to amount to a considerable proportion of the original price of the vehicle.

There has never been a time when motor-vehicle manufacturers and dealers could rely for their profits on only the sale of repair parts, maintenance labor and accessories. In fact, the dealer frequently found that the profits which should have accrued to him from merchandising motor vehicles were disappearing in the service department, erroneously considered by laymen to be a gold mine.

For years, therefore, service was regarded in the industry as a necessary evil. It was costly and painful but it could not be escaped.

Multiplicity of manufacturing units, wide variations in design, rapid development of the art and consequent frequent and radical change of models by the same manufacturers, lack of parts standardization and scarcity of competent mechanics familiar with the intricacies of different jobs, put this problem of servicing their customer's vehicles directly up to the dealers and the manufacturers. They could not "pass the buck."

THE INDUSTRY'S DUTY

So the problem grew up in the industry. The public never has bought mere motor cars and trucks. It has always purchased transportation and rightfully looked to the dealer and the manufacturer to see to it that the vehicles they made and sold were kept in efficient operation and at a reasonable cost.

Only within the last few years has the industry as a whole faced this problem squarely, and endeavored to cooperate in finding a solution satisfactory to all. But those few years have been exceedingly fruitful of results.

THE VALENTINE TROUPE
From Left to Right These Are L. B. Valentine, L. V. Pulsifer, Russel Rogers and H. J. Hoffman

We now know that, far from being an unproductive parasite on the industry, the servicing of motor vehicles can be made simultaneously satisfactory to the car-owner and profitable to the dealer and manufacturer. That is tremendously stimulating to us.

IMMENSITY OF SERVICE BUSINESS

Service is now a business of immense proportions. It is estimated that the cost of service last year in this Country was $2,500,000,000. This figure includes parts, labor and accessories, but not gasoline or oil. The total amount invested in new cars and trucks last year was approximately $3,000,000,000.

There is no reason why the service business cannot be so conducted that it will not only be entirely fair to the car-owner but be accepted by him as fair. Without question, the volume of this business will soon equal that of the sale of new vehicles.

COOPERATION NEEDED

Service is as yet far from being perfect. The industry appreciates that it is one of its major problems; that it is vitally important to every part of the industry and warrants the fullest measure of cooperation of all looking toward the solution of this problem.

The problem of service assumed such proportions that it could not be kept in the background as something of which the industry was ashamed. Education is a vital element in improving service. We hope to carry to the field personnel and to the public a better understanding of those policies and procedures which are essential to the merchandising of service on a uniformly fair, satisfactory, efficient and reasonably profitable basis.

FLAT-RATES

The practice of selling repairs on a contract fixed-price basis has, I believe, done more than any other one thing to remove suspicion of the service-station on

the part of the car-owner. He can now have repair work done with exact knowledge in advance of the expense to which he is committing himself. There is not the element of uncertainty that existed under the old "time-and-material" system. Today, any differences of opinion as to the predetermined price of contract work can be settled before the work is undertaken.

Service-Manager and Engineer

After study, from the standpoint of maintenance, the engineers have designed the various units of motor vehicles so that these have greater simplicity, accessibility and interchangeability. Sessions like these of the service-managers of the members of the National Automobile Chamber of Commerce with members of the Society, at which representatives of all branches of the industry are welcome, are of great importance. The discussions had at them should be given careful study. Than service, there is no other present problem of the industry in connection with which cooperative effort can be more productive of general good.

H. L. Horning expressed the opinion that "our service problems are 90 per cent psychological." He emphasized the importance of the customer understanding the attitude, the good faith and the product of the manufacturer. A complaint, once made, is elaborated in the mind of the complainer. The wise customer looks for assurance that the firm with which he is about to deal is fair. Having that assurance, he places his dependence mainly on being treated right. Mr. Horning said: "Know your man and give him what is at the bottom of all economics, satisfaction; nothing short of that is adequate."

Nitrocellulose Automobile Finishes

At the morning session of November 18, L. Valentine Pulsifer, chief chemist of Valentine & Co., gave a "laboratory talk" on the subject of nitrocellulose automobile finishes. He conducted a few simple experiments during this talk and distributed for study samples of finishes pertinent to the discussion. He explained the effect of the nitration of cotton, which is the most commonly used form of cellulose in the lacquer industry. Nitrated cotton, when ignited, burns instantaneously. It dissolves much more quickly than does raw cotton.

The simplest form of nitrocellulose lacquer is one grade of cotton dissolved in one simple solvent, acetone, for example. Nitrated cotton can be classified in three groups as follows: artificial-leather cottons, lacquer and film cottons, and explosive cottons. The basic cause of blushing is in the solvent-content of the lacquer. A properly balanced lacquer is apt to be spoiled by the addition of the wrong thinner.

A lacquer contains, in addition to nitrocellulose and solvents, (*a*) both low and high-boiling non-solvents or diluents, (*b*) plastisizers or "softners" added to increase the flexibility and (*c*) gums or resins used to add body and fulness. Mr. Pulsifer said that it is possible to make clear nitrocellulose lacquers which, in outdoor exposure, will outwear the most durable oleoresinous varnishes. The actinic or chemical rays in sunlight are the chief enemy of nitrocellulose lacquer. A remarkable increase in durability can be achieved by shutting out the sunlight with pigment. The wing dope used on the United States Army Round-the-World airplanes was protected from sunlight by pigmenting the last two coats of dope and finishing the whole with two coats of varnish. Mr. Pulsifer said that when the aircraft returned to San Diego their original wing-finish was in good condition.

Because of the poor adhesion of many types of nitrocellulose lacquer on flat surfaces and the tendency to develop upsetting factors of expansion and contraction, the engineering of a complete nitrocellulose painting system presents far greater difficulties than does a typical paint-and-varnish system. In addition to undue contraction of some lacquers, the difficulty is securing the proper relative balance in elasticity. Each added coat becomes to a certain extent an integral part of each and every preceding coat. Ordinary paint systems are essentially laminated structures with each coat stuck to but not otherwise affecting the coats above and below it, whereas a nitrocellulose system corresponds more in structure to an alloy and consequently the interrelation of the different coats is much more difficult to balance properly.

This accounts for the failure of many attempts to produce complete nitrocellulose systems and the recommendation by some lacquer manufacturers that varnish-type undercoats, preferably force-dried, be used under nitrocellulose finishing-coats. When this is done, a substantial part of the remarkable time, labor and fuel saving made possible by a complete air-dry nitrocellulose system is lost. While it is true that most nitrocellulose primers and surfacers lack either adhesion and elasticity or else are too tough to surface properly, it is possible to produce properly balanced materials of this type affording all-round qualities far superior to any varnish-type undercoats ever produced, Mr. Pulsifer said.

In connection with the use of water on surfacers, either with rubbing block or wet sandpaper, the tremendous difference in porosity or permeability between a varnish-type roughstuff and a highly developed nitrocellulose surfacer is interesting. This is brought out in the figures presented below showing the amount of water absorbed by three different panels after being immersed in water for 48 hr. and for 30 days.

Type of Panel	Water Absorbed in Grams after Immersion for	
	48 Hr.	30 Days
Bare Wood	25.0	69.0
Varnish-Type Primer and Surfacer	17.0	63.0
Nitrocellulose-Type Primer and Surfacer	0.5	9.0

This explains why, after rubbing roughstuff, all the specifications call for at least an overnight dry to allow the absorbed moisture to evaporate, and why it is safe to begin coating a nitrocellulose surfacer of this type as soon after rubbing or wetsanding as the surface moisture has dried off. When the oldtime painter was worried by what he called the "suction" of his undercoats, the water went through the roughstuff into the wood almost as fast as it did into the bare wood panel. The resistance to the penetration of moisture by a given paint material varies almost directly with the thickness of the film. The total film-thickness of the nitrocellulose primer and surfacer coats does not exceed one-half that of the varnish-type primer and roughstuff coats.

Mr. Pulsifer showed two railroad-steel panels on which extremely heavy coats of surfacer had been knifed. He said that very heavy coats of nitrocellulose materials can be used. He emphasized the time saving in production and the flexibility in the choice of the final treatment made possible by the adoption of the nitrocellulose system from the metal out. One system requires 2 days in production, without force-drying and with only one "operation" other than the application of the materials, namely, the water sanding of the surfacer. This system consists of one coat of primer, three of surfacer, spot putty on first coat of surfacer if needed, three coats of finishing-enamel and stripe, all nitrocellulose materials. Adding the operation of polishing the final surface gives a three-day production-schedule. The final nitrocellulose enamel coat may be rubbed down and two coats of finishing-varnish applied. This, in Mr. Pulsifer's opinion, gives a permanent depth of luster and brilliancy that cannot be equalled by the use of varnish-type undercoats. This nitrocellulose system requires 6 days in production and, it was stated, gives a more durable result than the system in which the best varnish-type undercoats are applied under the same two finishing-varnishes, even if a 6-week production schedule is used.

Finishing-varnishes have shown frequently premature perishing and scaling over lacquers. In some cases the

character of the volatile plastic or softener used in the lacquer is the prime cause; in other cases the character of the finishing-varnish used has been chiefly to blame, for one coat of a thin finishing-varnish will sometimes scale off of a lacquer due simply to poor adhesion and to the wide difference in the factors of expansion and contraction of the varnish and the lacquer. The same condition sometimes exists when a thin coat of clear finishing-varnish is applied over a baked black enamel. Careful rubbing-down of the lacquer, allowing a night for the evaporation of any high-boiling solvents still remaining in the lacquer coat, plus the use of a very heavy coat of an extremely elastic varnish, or, better still, the use of two finishing-varnish coats of properly interbalanced elasticity will yield the best results. All this is, of course, predicated on the lacquer being of a type that does not naturally "shed" varnish.

Luster on nitrocellulose automobile-finishes is at present obtainable only through a polishing operation, and this luster is much less deep and brilliant than that obtainable with finishing-varnish in large production and costs heavily in labor. The future holds the possibility of deep lustrous durable clear nitrocellulose lacquers but for the present they do not exist.

Nitrocellulose Finishes from the Service Angle

Dealing first with the repair of a damaged panel on a nitrocellulose finished body, Mr. Pulsifer advised, first, bumping out or straightening the damaged place and then making sure whether wax of any kind has been used on the surface. He continued: if it has, wash carefully with a mixture of benzol and high-test gasoline. Then sand-down the edges of the damaged spot and spray on the necessary number of coats of the original nitrocellulose enamel, covering as much of the surrounding surface as may be necessary. If the job is to be rubbed and polished or rubbed and varnished, this will include the whole panel, unless fading or discoloration has taken place. If puttying-up before refinishing is necessary, prime and spot-putty, using nitrocellulose materials, and refinish. If a refinish is desired using either the same or a new color, the condition of the old surface will indicate the need of its removal or not. If it is necessary to remove the old nitrocellulose finish, everything should be taken off to the metal, using lacquer solvent or thinner, and the metal made absolutely clean, free from grease, oil, moisture and rust. Then refinish according to the system used, remembering that if air-dry varnish-type undercoats are used, more time must be given for them to harden than would be the case if they were to be finished with varnish-type materials. This is where the service-station unequipped with force-drying ovens will save much time by the use of a complete nitrocellulose system, and the more quickly satisfactory refinished jobs can be turned out.

If the car to be refinished has been finished originally with a varnish-type system, the only safe procedure is to take everything off down to the metal. Clean this thoroughly and carefully and build up from the primer out. In the case of parts or bodies furnished in black baking-enamel, this material need not be removed, but can be surfaced-down carefully either with water sandpaper or powdered pumice-stone and water, wiped off with denatured alcohol and coated with the nitrocellulose finishing-enamel direct. In case the original finish consisted of nitrocellulose lacquer over varnish-type undercoats and it is desired to refinish without removing the old finish, care must be used not to soften-up the varnish-type undercoats through the old nitrocellulose lacquer by the application of heavy lacquer coats, as swelling and blistering, followed by chipping and peeling, will result. The old lacquer-surface must be well rubbed-down and absolutely free from all grease, oil, wax or moisture.

When finishing-varnish has been used over a nitrocellulose system and refinishing becomes necessary, the perished finishing-varnish may be removed by a mixture of solvents that does not touch the nitrocellulose underneath; the latter then rubbed smooth and the job refinished with either more finishing-varnish or nitrocellulose finishing-enamel.

Natural-wood garnish-rails, spokes, instrument-boards, vanity boxes and steering-wheels can be refinished quickly with the right kind of clear nitrocellulose lacquer. If, after removing the old finish, restaining and filling is not necessary, spray on about four coats of suitable lacquer on one day, and rub the polish on the next day, using a buffing-wheel. If stain and filler are needed, water-stain and fill with a good paste-filler tinted to the right shade with japan color; allow the filler ample time to dry, 50 per cent more time than if it were to be varnished, and proceed with the spray coats of clear lacquer.

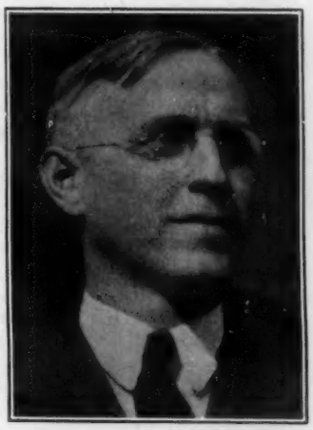
Inflammability of Material

One other service angle should be mentioned, the much greater inflammability of the vapors from lacquer than those from varnish. Spraying should be done in a separate room, if possible, and a suitable exhaust system should be used, preferably a spray hood and exhaust combined. Great care should be taken that no sparks, electric or other, occur where lacquers are sprayed in quantity, on account of the low flash-point of the vapors produced. The flash-point of some of the material is as low as the freezing-point on the fahrenheit scale, and of others even lower. In most of the high-grade varnish and paint products the flash-point is over 105 deg. fahr. This is a phase of the subject that has been neglected or overlooked in some talks I have heard on the subject.

In reply to questions, Mr. Pulsifer said that nitrocellulose materials set so rapidly that it is very difficult to apply them with a brush. The nitrocellulose finish is far harder than any varnish. The trouble with some colors is about the same as that encountered in the old practice. The expense involved in the nitrocellulose system is probably less than that of former systems. All the pigment being at the surface of a nitrocellulose finish, it is difficult to get a good white finish with the new method. Water-cooled cast-iron cylinders can be surfaced by the process.

SERVICING OF ELECTRICAL EQUIPMENT

Standardization Work of the Automotive Electric Association



A. M. Dudley

A. M. Dudley, manager of the automotive engineering department of the Westinghouse Electric & Mfg. Co., presented the concluding paper of the opening session. He told of the purpose of the Standardization Committee of the Automotive Electric Association, with reference particularly to generator and motor ratings and to the wiring and the installation of electrical equipment of gasoline automobiles.

Mr. Dudley said in part:

The idealist says, "Let us standardize all the generators and starting motors and ignition distributors made by all manufacturers so that they will not only fit mechanically on any motor-car engine, but also so that their performance will be exactly the same and that all armatures and bearings and brushes will be interchangeable regardless of

make." That certainly would be wonderful. But most practical engineers do not expect to live long enough to see it. On the other hand, the pessimist on standardization says, "There is no use trying to standardize. Commercial conditions and the whims of individual designers will always prevent it anyway. A job that involves the production of 10,000 units a year is big enough to be considered a standard, whether it is like anything else in the world or not."

Both of these viewpoints are wrong and both are partly right. Any standardization scheme that does not recognize the necessity for the art of individual design will meet with something far less than 100-per cent accomplishment. But, after all these things are considered, there is a zone wherein standardization of certain features, functions or performances would be a distinct gain to the industry as a whole, without being a handicap to any manufacturer.

The Automotive Electric Association felt that the old standards of mechanical dimensions for electrical equipment adopted by the Society of Automotive Engineers were not widely enough used. Many explanations can be given for this, each more or less logical. In some cases the design of the engine was such that S. A. E. Standards could not easily be worked in. In other cases, the designer of a job working for distinctive results seemed to feel that special electrical equipment was desirable. Again, insufficient attention and thought was put upon the problem of making possible the adoption of standards.

Discussion indicated that practically an agreement existed among all electrical-equipment manufacturers as to the ratings and speeds of generators and the gear-ratios and torques of starting-motors, and the work of selecting suitable generator and motor ratings for all classes of cars was initiated.

It is hoped that, when these ratings shall have been reduced to general use, further standardization of mechanical mounting methods and dimensions can be taken up. In the consideration of the motor and generator problem, it became evident that good practice in the matter of installation and wiring should be recognized, and certain rules were developed and adopted.

Service Work

In what way would the adoption of these standards simplify service work? The greatest advantage would be a considerable reduction in the number of motor and generator ratings listed by each electrical-equipment manufacturer. This would mean a reduction in the amount of stock of renewal parts that would have been carried by the service-stations. The service-stations would have to be familiar with many less performance and test data to check the operation of a unit after a major repair. Since electrical units of the same rating are interchangeable, emergency replacements would be possible in some cases by the use of another make of unit than that originally furnished. Any manufacturer would prefer to have made a quick temporary repair by such substitution, rather than have a car-owner disgruntled because his car is tied up for days for lack of a spare of the original make. "No. 1 Generator," or a "No. 3 motor," would be a definite thing. The service-station men, after observing the size of a car and its gear-ratio and motor and generator units, would know whether its electrical equipment was liberal or closely rated. If the wiring of the installation data were followed, all cars of a class would be similarly wired, saving time in checking the wiring. A color scheme of wiring would facilitate greatly the locating and remedying of wiring trouble. The use of the standards in the wiring would assure in general a better job, and one that could be more easily put right in case of trouble. Standardization, where it is logical and can be worked out, saves time, energy and money.

P. J. Durham said that, with five standard sizes of generator in use, there would be almost the minimum number possible of generator mountings. At the present time his firm carries in stock nearly 300 "types" of generator armature in stock. Probably 500 different "types" or sizes of these are in existence that are not interchangeable. And there are nearly 150 different starting-motor armatures. One make of car has had an almost unbelievable variety of electrical-equipment installation. Some service-stations carry 50 different types of ignition coil and 200 different types of ignition switch.

In Mr. Durham's opinion, there should be a standard installation. The connections in the wiring circuits are most important. A slightly defective contact causes an armature to burn out.

In reply to questions, Mr. Dudley said that it is the intention to develop ratings of motors and generators for use in connection with heavy-duty engines. No standard of the minimum voltage to secure ignition has been established but about 2 volts is required for this purpose.

ETHYLIZED GASOLINE NON-POISONOUS

Midgley So States When Describing Its Action in Engine at Service Meeting

While concentrated tetra-ethyl lead is admittedly poisonous and its manufacture hazardous, extensive investigations made by the Bureau of Mines have failed to reveal the possibility of any danger to the public health resulting from the general use of this material in very low concentrations in motor fuel. Considerable apprehension has resulted from press reports of the deplorable fatalities in laboratories manufacturing tetra-ethyl lead, and Thomas Midgley, Jr., felt it desirable to correct possible misinterpretations of these reports when he addressed the Service Meeting in Cleveland. In the case of the recent Bayway laboratory misfortune, Mr. Midgley said that a new method of manufacturing tetra-ethyl lead was being tried experimentally at the time and that inexperience with the method was largely responsible for the fatalities. It must be remembered that only 1 part of this concentrated material is employed in 1300 parts of gasoline. Mr. Midgley said that in this diluted form the tetra-ethyl lead is no more dangerous to handle or burn than denatured alcohol which is adulterated with poisonous materials.

Aside from its commercial possibilities, gasoline treated with tetra-ethyl lead has been introduced as one means of conserving the petroleum supply. Low-compression engines are known to be thermally inefficient, yet high-compression engines are impractical for motor cars because they develop detonation or knocking to a disagreeable degree. It is generally conceded that ethylized gasoline overcomes this detonating phenomenon, so it follows that its general use will make is possible to employ higher engine compressions with a resulting increase in fuel economy. Benzol, alcohol and some other materials are known to have anti-knock properties, but none of these other materials exists in sufficient quantity to treat all of the fuel that is used in cars today. For example, only enough benzol is available to treat about 5 per cent of the present fuel consumed annually. Also, only sufficient "high-test" gasoline is available to supply 25 per cent of the cars in use.

200,000,000 Gal. of Ethyl Gasoline Sold and No Ill Effects

Mr. Midgley treated the effects of ethyl gasoline under two heads: first, its effect on human beings; second, its effect on the engine. Concentrated tetra-ethyl lead is one-twentieth as poisonous as bichloride of mercury. Absorbed through the skin or inhaled as a vapor, it is dangerous in this form. When employed in concentrations of 1 to 1300 it has been found harmless, as evidenced by the fact that 200,000,000 gal. of ethyl gasoline have been sold without the reporting of a single instance of poisoning resulting from either its handling or use. It is interesting to know that tetra-ethyl lead has been rejected for chemical warfare use,

yet chlorine gas is accepted as sufficiently deadly for this service. On the other hand, we find chlorine used generally for the purification of drinking water, thus illustrating how very weak solutions of a deadly poison may be perfectly harmless.

In the Bureau of Mines tests previously mentioned, small animals were exposed to air containing ethyl-gas fumes in higher concentrations than could be normally expected should this fuel come into general use. Such exposure had no deleterious effect upon the animals and their bodies were found to contain no lead at the end of a period of 8 months. Other tests showed that of the infinitely small amount of lead inhaled by human beings exposed to ethyl-gas fumes, fully 90 per cent was exhaled. The remaining 10 per cent was not considered harmful, according to Mr. Midgley's statement.

These tests by the Bureau of Mines are being continued for the purpose of studying the possible effect of misusing gasoline treated with tetra-ethyl lead. Some examples of the cases receiving study are: the use of ethyl gasoline as a cleaning fluid, using it to wash motor-car parts and burning it in gasoline stoves. The last-mentioned use has one dangerous possibility; if bread is toasted over an ethyl gasoline flame, the person eating the toast will eventually become poisoned. So far, this is the only example of misuse that has shown dangerous possibilities.

Carbon Deposits Discolored by Ethyl Gas

Mr. Midgley stressed the importance of the garage mechanic knowing and understanding the effects of ethyl gasoline on the engine and its parts. No action of any kind occurs previous to the instant the gas is burned in the combustion-chamber. That is to say, there is no corrosive action on any of the parts of the gasoline system, nor is the functioning of the carbureter affected in any way. Mr. Midgley cited all manner of complaints made by owners who attributed their troubles to ethyl gasoline. Some owners had experienced clogging of gasoline-strainer screens, but an analysis of the sediment on the screens showed them to be devoid of lead. One user even registered the complaint that the new gasoline made his feet hot!

The most noticeable effect left by the burned ethyl gasoline is presented in the discoloration of the carbon deposit from its customary black to a reddish and in some cases a gray deposit. The reddish deposit is often mistaken for rust, and the ethyl gasoline is accused of promoting rust in the cylinder. When unadulterated tetra-ethyl lead is burned along with the fuel, it leaves behind a solid ash deposit that is principally lead oxide. This material will attack and corrode the spark-plug terminals. To overcome this trouble, bromide-bearing compounds are used in the ethylizing solution and these act to change the lead oxide to lead bromide when combustion takes place. Most of this lead bromide is carried out through the exhaust, Mr. Midgley said, but a certain amount remains, and it is this material that alters the color of the carbon deposit.

Sticking Valves Prevented by Periodic Lubrication

Some difficulty with sticking exhaust-valves has been reported from the field when ethyl gasoline is used. Mr. Midgley attributes this to the tendency of the lead bromide to absorb that part of the lubricating oil which ordinarily reaches the valves from the cylinder. The deposit acts as a sponge, being blown out through the exhaust and carrying the oil with it. The remedy for this trouble, as suggested by Mr. Midgley, is to lubricate the valve-stems from an oil-can every 1000 miles.

Another effect that is noted when ethyl gasoline is used, is a discoloration of the crankcase lubricant. This will be changed from the customary black to a chocolate color. Many samples of this discolored oil have been analyzed and in no case have sufficient lead materials been present to produce any deleterious effects on the engine parts.

Discussion Brings Out Additional Information

Contrary to the belief of many users, ethyl gasoline has no effect upon starting. Where trouble is encountered when the change-over is made to ethyl gasoline, it is invariably due to the owner having previously used and set the carbureter to operate on high-test gasoline. High-test gasoline will start easier, of course, because of its higher volatility. Ethyl gasoline reaching the lubricating oil will not affect its flash or fire-point characteristics. Practically all cars in use today will benefit by the use of ethyl gasoline, said Mr. Midgley. While the fuel consumption may not be reduced much, the annoying detonation when the engine is laboring will be eliminated. Ethyl gasoline will have no effect on lubricants that are a blend of castor and mineral oil. Tests have been made which support the statement that ethyl gasoline has no effect upon cylinder-wall or piston wear. While some users testify favorably to the carbon-removing properties of ethyl gasoline, Mr. Midgley stated that no such claims are made by the manufacturers of the fuel.

George H. Duck

Thomas Midgley, Jr.

Mr. Midgley said that Boycite, when used in combination with ethyl gasoline, has a tendency to prevent the bromide compounds from reacting on the lead oxide. This results in depositing the latter material instead of lead bromide, and spark-plug corrosion will follow. The effect of using a high concentration of tetra-ethyl lead in gasoline was studied during the recent long flight of the Shenandoah. Some spark-plug trouble was experienced, but the Navy is attacking this with characteristic foresight and is attempting to make plugs that will stand the service rather than change the fuel.

6 to 1 Compression-Ratio Predicted

Mr. Midgley predicted that just as soon as country-wide distribution of ethyl gasoline has been accomplished, higher-compression engines would be used in motor cars. The sale of the new fuel will not be limited to one refiner. When this time arrives, Mr. Midgley expects to see compression-ratios of 6 to 1 and 6½ to 1 in general use. Such high ratios are practical with the present-day concentration of tetra-ethyl lead in the fuel. Referring to results of tests made by a British engineer, the conclusions of which were not entirely favorable to the use of tetra-ethyl lead as a knock deterrent, Mr. Midgley said that these did not represent tests of properly prepared ethyl gasoline. Apparently, the British investigator used only the pure tetra-ethyl lead material in the fuel that was tested and did not incorporate the other ingredients that are now an essential part of the ethyl solution.

J. W. Swan expressed the hope that some day in the future the automobile engineers and the petroleum technologists could standardize on one motor fuel for universal distribution and consumption. Should this ideal ever be achieved, the carbureter and manifold designers would be enabled to produce devices that would give more nearly uniform results. He believed that carbon deposits can be eliminated when it becomes possible to effect complete combustion of the fuel in the cylinder.

More Engineering Needed in Service

Following the discussion of ethyl gasoline, George H. Duck read a most interesting paper on the importance of introducing more technical and engineering knowledge and experience into the supervision of maintenance work, particularly in the motor-haulage and motorbus fields. The major part of Mr. Duck's paper was made up of quotations from communications that he had received from motor-transport engineers. They indicated that maintenance is primarily an engineering operation which calls for the analytical methods of the technically trained man.

President H. M. Crane gave a most pertinent commentary on engineers and their place in service work. Not all technical graduates will fit into this work. Contrary to the practice followed by most managerial executives, it is impossible to consider all engineers as being grouped in a single class. An engineer with an inventive temperment would do more harm than good in the average repair-shop, yet he would be extremely valuable to a laboratory. Mr. Crane expressed the hope that the day will come when vehicles will be designed with the ultimate or over-all cost in mind instead of the first cost. The present-day practice of shipping cars from the factories in a semi-finished condition makes it doubly important that technical men be employed in the dealers' service establishments. By this Mr. Crane meant that some degree of engineering ability is needed to make the finer adjustments of carbureters, brakes, clutches and other details which cannot be given precise adjustment under the quantity-production conditions prevailing in the modern motor-car factory.

SERVICING PASSENGER CARS AND TRUCKS

Packard and General Motors Truck Systems Described by Their Service-Managers

At the session held on the morning of Nov. 19, consideration was given in a specific way to the organizing and the conducting of service systems for passenger cars and to the utilizing of motor-truck service-records. Two papers were presented, the authors of these being respectively H. N. Davock, technical service-manager of the Packard Motor Car Co., and S. V. Norton, service-manager of the General Motors Truck Co. Mr. Davock's paper, which is printed in full elsewhere in this issue of THE JOURNAL, dealt with service problems encountered at the factory and in the field. It confirmed and amplified what was said by Chairman Macauley, of the National Automobile Chamber of Commerce Service Committee, in his introductory remarks at the Service Meeting.

Past-President Bachman said that such large-scale accomplishments as Mr. Davock described were very gratifying. Speaking of reports of dissatisfaction on the part of the public as to the way service is handled in general, he pointed out that nobody enjoys paying bills for repair work; the dark side of the service business is the dissatisfaction of the customer. It is important that the methods followed be correct and that the prices charged appear to be reasonable. The prices of repair parts have been exorbitant. This has been the cause of the foundation of the "pirate" parts business. In some cases goodwill has been wrecked by unfair charges.

HARLOW N. DAVOCK

THOMAS A. STALKER

J. Howard Pile was of the opinion that the investigations the Packard Company had made were very valuable, as the variation in overhead expense is a more important factor than that in labor charge, especially in operations in large cities. He referred to conferences on the subject that had been held in New York City of auditors and dealers, under the auspices of the Automotive Service Association. Delay in the receipt of parts, as well as other delays, increase overhead expense.

H. R. Cobleigh, secretary of service of the National Automobile Chamber of Commerce, stated that the definition of a pirate part is a part that infringes a patent or is sold under a misrepresentation and nothing else. He felt that the profits from service should be as high as those from vehicle sales. Proper accounting allocates expenses correctly. One dealer had reported that he would not be in the new-car business except for the purpose of furnishing work to his service-station. His profits came from the latter.

A. B. Cumner, a member of the National Automobile Chamber of Commerce Service Committee, expressed the opinion that the tendency in the servicing of motor vehicles will be in the direction of more widely scattered work; that is, the concentration of service work at central stations will be relatively less. Passenger-car owners are apt to patronize independent service-stations located near their residences.

Thomas A. Stalker, of the Packard Company, said that every service-station must study its costs to determine whether it is located in the right place. Service-stations should not, of course, always be combined with salesrooms. In connection with prices on repair operations, he reported that surprisingly few changes had been made by his company after the prices were once set. They were determined originally largely according to the opinion expressed by men in the field. Time-studies are made to check the propriety of the charges. Reduction of charges is due largely to economies effected by the use of special tools. For every flat-rate operation, a separate card showing the amount of time taken for it should be kept. The company knows, for example, how much time a special tool for compressing the clutch spring will save. The service-stations are disposed to purchase the special tools they need. Special tools should not, naturally, be bought unless they will justify their cost. There are about 500 operations on the Packard Six. Thirty-five or 40 of these constitute 85 per cent of the repair business. The operation cards indicate the relative efficiency of the mechanics.

Motor-Truck Service-Records

Mr. Norton pointed out that, to speak with authority, the service manager must have evidence based upon definite records of many vehicles from service-stations located in all parts of the Country. Moreover, the records must be compiled and presented in the most convincing and helpful way possible.

The manufacturing committee of the General Motors Truck Co. consists of the heads of the principal departments of the plant. The organization of the service department is divided into three groups: office, factory and field. Division 3 of the factory group plays an important part in the scheme. Inasmuch as the service department is responsible for keeping the trucks running after they are sold, the final inspection is handled by the service department, instead of by the production department; contrary to the practice of the majority of car and truck factories. This arrangement, Mr. Norton said, tends to maintain the quality of the output, as the service department is naturally more interested in quality than quantity.

Final Inspection Handled by Service Department

When the production is running normally, the inspection of chassis is handled by the following groups, under the

direction of the final inspector, who reports directly to the service manager:

(1) Chassis-Line Inspectors
(2) Test-Room Inspectors
(3) Special-Equipment Inspectors
(4) Final-Assembly Inspectors
(5) Loading-Dock Inspectors

Field Service Inspections

To obtain a check on both the production department and the service inspection division, the branches and distributors are provided with service-inspection report-forms. These are divided into some 60 divisions that are based upon records that have been kept for many years by the engineering department. The branches and distributors check the condition of new chassis when they arrive at their destination.

In the field, the conditions complained of by the operator are regarded as the symptoms of the trouble, and the conditions found by the service-station as the causes of the complaint. The actions taken by the service-station to correct the troubles indicate whether the service-station is using the latest suggestions made by the factory.

When the company wishes to check up on a given trouble, the complete reports that have been received furnish dependable information as to its extent, and stampedes that might be occasioned by alarming letters or verbal reports from individual service-stations can be avoided. At the same time, prompt action can be taken if the trouble is becoming widespread, before it reaches the proportions of an epidemic. The service complaint-file embodies in compact and accessible form the latest information on complaints received from all available sources and is looked upon as most dependable and valuable.

At conferences of field men at the factory, the most successful method of getting the information desired relative to troubles has been to furnish each delegate with a parts-book for each model, and to go through it page by page asking for comments and criticisms on the various assemblies and parts described. The notes of all conferences, held in the field or at the factory, are filed in the technical service division and become the basis of following up the engineering, the production and the purchasing departments for improvements, as well as of reports from the service manager at the manufacturing committee meetings. The necessary contact is maintained with the engineering department through the technical service engineer.

To compare the number of parts credited as being defective with the number of parts disbursed in a given period, a summary is made every 6 months by parts or assemblies for the various models. A copy of this summary is sent to the chief engineer and is taken into consideration when recommendations for changes or improvements in service parts are made.

The stock-ledger division studies constantly the records of receipts and disbursements. If the disbursements of any parts or assemblies are abnormal or excite suspicion, the subject is investigated immediately.

The attempt is to make a record of experience in both producing and servicing the trucks so that the service department, through its voice in the manufacturing committee and in every other way, can contribute to the betterment of the product. The service engineer attached to the technical division follows up the complaints recorded and, in connection with the engineering department, works out practical remedies. Bulletins are then issued to the field organization, notifying the service-stations of improvements in parts or in methods of service. It has been found that the other departments turn more and more to the service department for dependable information as to the quality and the performance of the product. In the field, the representatives of the service department are received with great favor.

F. J. Wells, of the Pierce-Arrow Motor Car Co., did not agree with Mr. Norton as to the advisability of the service department acting as the quality division and exercising control over the product before it goes into the field. He thought that it would be best for the service department, in time of trouble, to be able to go to the engineering and the production departments to record complaints and seek remedies. It falls to the lot of the service department to bring up the disturbing things.

Mr. Wells approved of the plan outlined by Mr. Norton for securing for the engineering department records of the performance of the product. These can be secured only through the service department.

In reply to Mr. Wells, Mr. Norton said that it is the duty of service managers to shoulder responsibility in a constructive way. The salesmen look to them as the guardians of quality. From the point of view of the public, the latter are responsible. In the General Motors Truck Co. the inspection work of the production and the service departments is coordinated. But the service department has the final word.

TRAINING MECHANICS

John Younger Analyzes Need for Training and Describes Present Methods

John Younger

Kipling in one of his immortal poems calls attention to the relations between the man and the machine. He concludes that about the machine there can be no doubt, "but what about the man?" This analysis was applied very forcefully by John Younger, editor of *Automotive Abstracts*, in his paper, Training Mechanics, that was presented at the concluding session of the Service Meeting.

It is obvious that the thousands of automobile mechanics who have the public safety in their hands should be at least as well-trained as plumbers, bricklayers or electricians. Notable exceptions to the general lack of attention to this important need are offered by the Young Men's Christian Association and the Knights of Columbus schools, technical high schools, and other organizations that offer practical courses in vocational training.

Some mechanics work with machines and others work with their hands. This indicates the necessity for specialization in training, but the education of either course should assure a thorough ground-work, covering the fundamentals upon which all automobile design and construction are based. In other words, the workman should know the "reason why."

At least two main methods of training mechanics are followed: (*a*) at a central point, as, for example, the manufacturing establishment and (*b*) at the local headquarters of the dealer. These methods may be satisfactorily joined. Fundamental training of a general nature may be well accomplished by technical high schools. Advanced or specialized training may be obtained upon completion of the high school course from a vocational school of one sort or another.

Mr. Younger in his paper devoted some time to the educational cooperation at Flint, Mich., between the Buick Co. and the Flint School of Technology. Students pay a tuition fee of $125 for a 12-weeks' course, each week consisting of 44 hr. spent in shops, 3 or 4 hr. per night additional being devoted to home study. Lessons and lectures are given in the morning, and in the afternoon the students come into actual contact with the cars themselves. Competent instructors endeavor to show the students the "one best way." Fifteen men per month graduate from this school and easily find employment in service-stations throughout the Country. In

many instances the training is continued in the service-station where conferences are held periodically.

The Ohio Buick Co., for example, puts a man through an apprenticeship, the first assignment being the greasing of new cars. From this he progresses, stage by stage, through the disassembly until he is able to diagnose troubles and to remedy them efficiently. The course is kept uptodate by the parent Buick service organization which conducts at least two service clinics each year for each territory. Those who attend these clinics are the service-managers and the leading mechanics in each territory. This work is further supplemented by detailed outlines issued by the factory.

Tests for Mechanics

Machinists can be examined superficially at least by determining their ability to use the micrometer and to read it accurately. Bench-hand applicants may be examined by giving them blocks of wood cut into various shapes and judging their intelligence in assembling them. "Trouble shooters" can be examined by giving them a car with some minor maladjustments and asking them to diagnose the trouble. Slides and motion pictures accompanied by brief talks can be used to advantage.

One difficulty in the training of mechanics is that of reaching the independent garage men who maintain no connection with a definite manufacturing organization. The average service-manager would accomplish much toward giving the customer satisfaction by distributing information to the independent men as well as to those connected with his own organization.

Courtesy and Human Nature

Mr. Younger emphasized the importance of teaching mechanics to be courteous and understanding of human nature. When these features are satisfactorily considered, a mechanic will be forgiven for many things; he will be instrumental in bringing new customers to the establishment and in keeping old ones.

It is worthwhile to teach the service man the fundamentals of business and economy, and to instill in him an interest and a pride that will make him more effective in his work.

High Spots of the Discussion

H. E. Repasz, Willys-Overland Co., in discussing Mr. Younger's paper stated that the industry can be no stronger than its service and that its service can be no stronger than the mechanical talent employed. The Willys-Overland Co. has devoted considerable time to the establishment of an adequate system of training. It uses the clinic method of teaching the master mechanics. Specialization was said to be greatly needed and it was felt that mechanics should be certified as to their ability just as other artisans are at present being certified.

H. R. Cobleigh, secretary of service, National Automobile Chamber of Commerce, called attention to one objection to certification, namely, the probability of unions being formed and the disadvantages of this result outweighing by far the advantages derived from licensing.

Fred C. Smith, in charge of the Young Men's Christian Association training of mechanics, stated that over $1,000,000,000 is being spent each year for the labor of mechanics. He believed that this fact alone should warrant the devoting of much greater attention to this problem.

Mr. Smith stated that the course of training should devote 10 per cent of the time to the teaching of facts applying to all makes of equipment, 20 per cent to laboratory experience on this equipment, 60 per cent to garage work and 10 per cent to the questions of human relationship and the handling of customers. Before a man is accepted for training, his adaptability to the training should be carefully ascertained. It should be the aim of every school to train the students so that they will become the type desired by the industry.

S. V. Norton, General Motors Truck Co., stated that efforts have been made by the National Automobile Chamber of Commerce and the Society to get the temper of the industry concerning Mr. Smith's question above mentioned. A questionnaire was sent by a joint committee to automobile manufacturers to learn if the manufacturers considered it feasible to establish a central school. The returns from this questionnaire were somewhat discouraging and the committee decided to turn to the existing agencies. Mr. Norton recommended that the committee make further efforts to bring this matter to a successful issue.

At the conclusion of the regular papers presented at this session, R. B. Perry described in more or less detail the Luberator method of top-end lubrication. Neil MacCoull, Texas Co., also contributed interesting material concerning lubrication.

Clyde Pelton, Swan Carbureter Co., who acted as chairman of the session, called attention to the necessity for a careful study of distribution. He referred to various manifold designs and cited one instance in which 310 cc. (18.39 cu. in.) of fuel collected in the manifold before the engine could be started.

A. W. MacCalmon, Vacuum Oil Co., emphasized the importance of maintaining engine temperatures at a sufficiently high point to bring about the elimination of unburned fuel from the crankcase.

BALLOON TIRES AND SERVICE

Hale Discusses Design, Proper Use and Servicing of Low-Pressure Tires

J. E. Hale

Any new development or innovation must be subjected to the tests of actual service before its advantages and disadvantages, strong points and weaknesses can be fully determined. The balloon tire offers no exception to this rule.

At the concluding session of the annual Service Meeting, J. E. Hale, manager of the development department, Firestone Tire & Rubber Co., in his paper entitled What the Service Department Needs to Know about Balloon Tires, reviewed the fundamental principles of balloon-tire design and discussed (*a*) the progress in adapting balloon tires to production cars, (*b*) the effects of balloon tires on the operation of cars, (*c*) the air-pressure problem and (*d*) other factors of importance in the successful use of the tires.

Attention was directed to the fact that *riding on air*, the most satisfactory cushioning medium, is actually brought about by the use of these tires. In contrast with the high-pressure cord tires, the newer type is designed so that the carcass itself does not support the load but merely acts with the tube as a container for the air.

Mr. Hale stated that a tire which renders 15,000 miles of service must revolve 10,000,000 times, which means that every part of the carcass must flex without failure 10,000,000 times. The tire has been adapted to the flexibility requirements above indicated by the use of a large section, the minimum number of plies and a specially designed tread construction.

Adapting Balloon Tires to Production Cars

In view of the fact that the first experimental balloon tires were built in October, 1922, and their first sale for change-overs took place in the fall of 1923, it is very significant to note, as an indication of the popularity of the low-pressure

type, that the company represented by Mr. Hale made shipments to manufacturers in the month of September, 1924, of 75 balloon tires to 1 high-pressure tire. This was exclusive of shipments for cars using the 30 x 3½-in. clincher type.

Tire Standardization

Summarizing briefly the existing unsatisfactory condition that applies to the lack of standardization for balloon tire sizes, Mr. Hale spoke of the hardships that are being imposed upon the tire dealer because of the necessity of his carrying in stock a big assortment that represents a large investment. It was pointed out, however, that in time this situation would be clarified automatically by the elimination of undesirable factors and unnecessary sizes.

Effects on Car Operation

As regards fuel consumption, figures obtained after extensive tests by a taxicab company indicated that the fuel consumption with balloon tires is slightly less than that with high-pressure tires. Coasting and acceleration characteristics were said not to be affected adversely by the new tires. Danger of loss of control when a blow-out occurs was believed to be negligible.

The necessity of using rebound checks or shock-absorbers, especially in changing over existing automobiles to balloon-tire equipment, was emphasized. It was felt that the tires should be expected to absorb road-surface irregularities of a minor character and to cushion the vehicle even to the point of eliminating their effect altogether, whereas the springs should enable the car to negotiate irregularities of a larger magnitude.

The load on balloon tires together with the greater area of tread in contact with the ground has brought about a condition of hard steering in the case of change-overs. But this difficulty has been largely overcome in new cars that are properly designed.

Front-wheel shimmy was considered by Mr. Hale to be logically classified as it takes place at low or high speeds, that is, at from 15 to 30 m.p.h. or at from 35 to 40 m.p.h. The proper treatment of this difficulty was said to be very baffling. Shimmy has been eliminated or lessened by a more careful layout of the steering-gear linkage, by eliminating the play and by other means. Different designs must be treated individually in the attempt to remedy this trouble. Wider rims were not believed to offer a solution. Some manufacturers have found that the situation is greatly relieved by the use of vertical king-pins.

Balloon Tire Service

Mr. Hale presented figures concerning balloon tire service that were based upon observations from 8,000,000 tire-miles of testing, supplemented by close contact with the adjustment branch of the organization with which he is associated. During the past 11 months only 1 tire out of every 5000 built has been returned for adjustment. No cases of tread or ply separation or of bead-failure have been reported during the entire year. *Perhaps the greatest cause of trouble was under-inflation*, which resulted in bruise-breaks or uneven front-tread wear. Figures were given to show that in taxicab service the drivers of cabs equipped with low-pressure tires reported only half as many flat tires as those who used the high-pressure type. The puncture hazard was said not to compare unfavorably with that of high-pressure tires.

Taking all these facts into consideration, the speaker was definitely convinced that balloon tires, when used in adequate size and properly inflated, will give greater durability and lower tire-mile cost than will high-pressure tires.

The Pressure Problem

Perhaps the outstanding feature of Mr. Hale's paper was the great emphasis placed upon the necessity of maintaining the air pressure at the specified point. This can only be brought about by frequent inspection and the exercise of great care to assure tightness of the valve or the valve-cap. The loss of a small quantity of air represents a comparatively large percentage of the total volume. It is thus necessary to maintain the pressure within narrow limits. Examples of front-tread wear, internal cracking, bruise-breaks and other causes of failure occasioned by under-inflation were shown.

Mr. Hale recommended that car manufacturers ask all purchasers to check the tire pressures weekly to insure that the prescribed inflation-pressure *for each type of car* is maintained. Tables were used to show the proper pressure for different makes and types.

Discussion Brings Out Interesting Points

A number of interesting questions were raised when Chairman C. S. Pelton opened the discussion of Mr. Hale's very interesting paper.

J. F. MacDonald, Ohio Buick Co., stated that although the public was ready for the balloon tire, yet the car and the service organizations were not prepared when the new tires were "exploded" on the market. He called attention to the need for cooperation between the tire and the automobile interests and the service-managers in bringing about the best solution of the problems that have arisen.

A representative of A. Schrader's Son in reply to a statement that tire valves would leak less if they were designed especially for balloon tires reported that although the present valves are very similar to those originally used on bicycle tires, yet the current type has been found in extensive tests to remain satisfactorily seated at pressures not exceeding 1 lb. per sq. in. He stated further that leaks are not caused, as is sometimes supposed, by a pulsating action that accompanies the motion of the tire. In fact, such pulsation was not found to exist.

A member stated that although the valve on a particular tire was carefully sealed, yet the tire lost from 10 to 15 per cent in pressures each week. John Younger, editor of *Automotive Abstracts*, mentioned the possibility, recently discussed in England, of explaining this leakage by the theory of osmosis. Mr. Hale replied that he did not believe this to be the cause and he further emphasized the necessity of screwing the valve-cap tightly in place. T. S. Kemble believed considerable valve leakage to be caused by particles of dirt on the valve-seat.

S. M. Schott, United States Tire Co., believed that leakage might take place around the base of the valve as a result of the rocking action of the valve that accompanies the motion of the tire. This was also said to cause excessive wear in cases where the valve is not properly anchored to the wheel. Mr. Schott stated that his company is studying this problem and that especial attention is being directed toward obtaining the proper seal between the valve and the tire and toward eliminating excessive valve-movement by the use of larger rim nuts. It was stated that many repairmen have trouble in properly handling a balloon-tire job but that an experienced workman should find no difficulty.

Attention was called by Mr. Schott to the fact that owing to the possibility of negotiating comfortably more severe road-conditions, balloon tires in the hands of the average driver receive much greater punishment than do the high-pressure type. Mr. Hale believed that the balloon tires could be properly called upon to withstand this abuse.

A member who had experienced 34 "flats" in 1250 miles asked about the effect of ruts upon the wear of the side-walls. Mr. Hale replied that his experience has shown this to be a negligible factor.

A. J. Scaife, White Motor Co., raised the question of wear resulting from an increase in the center to center distance of the treads. Mr. Hale replied that no trouble had arisen from this source.

A member called attention to the effect of balloon-tire equipment upon the turning radius when the tire comes in contact with the drag-link. It was stated that the manufacturers of automobiles and tires can easily eliminate this difficulty.

SHIMMY, BALLOONS AND AIR-CLEANERS

They Will Feature Detroit Annual Meeting Along with Aeronautics and Body Topics

Wheel shimmy, that pernicious malady of mystery which is defying the cunning of nearly all car designers, will be one of the principal topics for discussion at the Annual Meeting of the Society in Detroit, Jan. 19 to 22. Accompanying it will be some of the other favorite automotive engineering subjects of the day. For example, our fabulous friend, the balloon tire, will be featured in one of the sessions. Experience has shown us that low-pressure air brings problems with it and these must be solved. Outstanding authorities will shed a bit of light on such matters as tread wear, desirable number of plies, aggravated jouncing and such other maladies as seem to need treatment.

It is a bit premature to announce the formal program with the names of the many engineers and scientists who will participate, but it is not too early to say that the Annual Meeting program is filled to the brim. It will suffice for the present to give some idea of the material that is to be presented. One feature paper will present an analysis of all-steel body design and manufacture. It will be given by the leading engineer in the all-metal body field. Contrasting with it will be a paper on the Weymann "stick-and-cloth" type of body that is increasing in popularity in European circles.

In the field of aeronautics an unusually valuable group of papers will be presented. They will treat of all-metal airplane design, all-metal airship design, the future plans of the Zeppelin engineers and the latest aeronautical engines and airplanes. Truly, this will be a remarkable group of papers, all by engineers prominent in the commercial aircraft business.

Instructive Exhibits and Demonstrations

This is not all! But why need more be said for the present? Is this not enough to give Society members some conception of the unusually fine program that awaits them in Detroit? Exhibits and demonstrations have not been mentioned. They will be featured this year as never before. This is bad news for the stay-at-homes who believe that the printed reports are adequate substitutes for personal attendance at the meeting. There will be just as much to SEE at the Annual Meeting as there will be to hear. Better put those dates down on your calendar now and make arrangements to obtain the full benefit of this great meeting.

HOW GRINDING WHEELS ARE MADE

New England Section Visits Norton Plant and Hears Valuable Papers

Grinding wheels, the materials that compose them, and their manufacture and use were described in a most comprehensive and fascinating manner at the meeting of the New England Section which was held at the Norton Co.'s plant, Worcester, Mass., on Nov. 19. Starting with an inspection of the Norton shops in the afternoon and ending with a series of extremely instructive talks in the evening, the members were given a most complete picture of the abrasive industry. No finer hospitality can be shown by an industrial organization than that accorded the visitors by the Norton executives.

After a short address of welcome by the chairman of the meeting, Howard W. Dunbar, the manufacture of abrasive wheels was described by Milton F. Beecher. Almost all grinding that is done today is done with artificial abrasives, said Mr. Beecher. These are of two general classes: those consisting of crystalline fused alumina and those consisting of silicon carbide. By adopting artificial abrasives, the grinding-wheel manufacturer is able to control the composition, the crystal structure and the physical properties of the material.

Crystalline fused abrasives are all made from the same basic material, bauxite, a rock of clay-like character that is mined in Arkansas. It contains an important percentage of alumina along with some iron, silica and minor constituents. Essentially, the job of manufacturing an abrasive from this ore is that of fusion and purification. This is accomplished in an electric arc furnace at the very high temperature of 2050 deg. cent. (3722 deg. fahr.).

Silicon-carbide abrasives are made from materials that are very dissimilar in character. These are coke, sand and sawdust. Silicon carbide consists of one molecule of carbon and one of silicon chemically combined. The coke furnishes the carbon and the sand the silicon for this combination. Sawdust is added to give the molten mass porosity, so that the carbon monoxide generated in the chemical combination of the materials can escape and be burnt in the furnace without danger to the workmen. Silicon carbide is manufactured in a carbon resistance furnace.

Bonds That Serve to Carry Abrasive Materials

Grinding wheels are manufactured from four principal bonds: vitrified, silicate, elastic and rubber. Probably from 80 to 85 per cent of the grinding wheels made are of the vitrified type. Vitrified or glassy bonds are made of various mixtures of clays and feldspars. The vitrified wheels are made by mixing this bond with the abrasive grain in large kettles. The resulting mixture is poured into a form to cast the wheel blank. This blank is put in a drier and then shaved and bored in a machine so that it is approximately the size of the finished wheel. It is then burned in furnaces at a temperature of 1300 deg. cent., or about 2400 deg. fahr. The firing time ranges from 6 days to several weeks, depending on the size of the wheels.

Silicate bonds are made of silicate of soda and clay. These are mixed thoroughly with the abrasive grain and the mixture is tamped into a mold. After forming, the silicate wheel is dried in a steam box and then sent to the kilns, where it is subjected to the relatively low temperature of 500 deg. fahr.

Elastic wheels are made with either natural or synthetic resin as a bond. Norton elastic wheels are bonded either with shellac or Bakelite. After the resin has been mixed with the abrasive grain, it is formed and sent to ovens, where the blank is baked at a temperature of 200 deg. fahr. Elastic wheels are relatively flexible and readily adapt themselves to cutting-off operations.

Rubber-bonded wheels are made by rolling the abrasive compound into rubber dough, then running the resulting mixture through a calendar to form sheets from which the wheel blanks are cut. These blanks are then vulcanized. Mr. Beecher described the importance of thorough inspection in grinding-wheel manufacture and showed how carefully all materials and operations are checked in the Norton Co.'s plant.

Comparative Merits of Abrasives Are Demonstrated

The relative merits of different abrasives and different bonds were illustrated graphically in a series of demonstrations made at the meeting by H. W. Wagner. By grinding specimens before the audience, Mr. Wagner showed that crystalline fused alumina wheels are best suited to the grinding of hard, brittle materials and less resistant metals of the non-ferrous classification. Silicon-carbide wheels are best adapted to the grinding of steel and the tougher materials.

W. T. Montague gave an exposition of recent developments in grinding machinery, his story of the progress of grinding since the introduction of the grinding wheel in 1885 being especially interesting. He said that the progress made in recent years has been along the line of multiple work, grinding such parts as piston-rings, roller-bearing cups and ball-bearing rings. Wider grinding wheels have been introduced to cover the entire surface of the work instead of traversing narrow-faced wheels across the ground surface. Mr. Mon-

tague made the interesting statement that 75 per cent of all grinding machines produced are for the use of the automotive and allied industries. So huge has the automotive industry become, that it must be regarded as the chief source of machine-tool business and the leading factor in forcing new developments in grinding-machine design and manufacture.

BATTERY PROBLEMS AT BOSTON

Boston members of the New England Section met on the evening of Nov. 5 at the Engineers Club and heard a paper by T. H. Dooling on problems encountered in the servicing of automotive batteries. A very lively discussion followed in which Mr. Dooling answered many questions put by the members.

SELECTING THE STEEL FOR THE JOB

Professor Moore of Illinois Discusses Significance of Properties at Buffalo

H. F. Moore

Engineers must not place too much reliance on the mere figures contained in material specifications or tests unless they know their significance and understand how to interpret them. This was the conclusion one reached after listening to the extremely interesting talk given by Prof. H. F. Moore, of the University of Illinois, before the November meeting of the Buffalo Section. Professor Moore has specialized in research on the physical properties of materials, particularly investigating the phenomena of fatigue failure under repeated and alternating stresses. He discussed each of the common physical tests made on materials and indicated the significance of each to the designer of motor vehicles.

With regard to the elastic-limit and the yield-point, Professor Moore expresed the opinion that for metals having a well-defined yield-point, this marks the beginning of a serious plastic action under stress and fixes the practical limit of static strength of such metal for use in most structural members and machine parts. For metals having no clearly defined yield-point, but with a fairly well-defined elastic-limit, the elastic-limit, which should not be too delicately determined, fixes the practical limit of static strength for metal for most machine parts and structural members. The yield-point should be reported only for tests that show a very clearly marked "drop of beam" and such tests should be run at slow speeds, especially for metals other than steel.

Tensile-Strength May Reflect Fatigue Characteristics

Tensile-strength is a well-defined property of nearly all materials. It is of direct significance as an index of static strength of such materials as rope, fabric, rubber and for metals used in chains, bolts and tie-rods. It is not of direct significance as an index of the strength of the metal used in most structural and machine parts, because such members, in most cases, cease to perform their structural duty long before the tensile-strength is developed. For wrought ferrous metals free from serious internal defects, the tensile-strength is also a fair index of the resistance to repeated stress or fatigue. Recently completed research makes it fairly certain that the ratio between the strength to resist repeated stress and the static tensile-strength is less for non-ferrous metals than for wrought iron and steel. Specimens of brittle materials often fail as the result of localized secondary stresses. To be of value, the tensile-strength of brittle materials must be determined with great care and the specimens must be perfectly formed.

Compressive strength is of value as an index of the static strength of brittle materials. Ductile materials have no well-defined compressive strength.

Elastic-Limit in Shear and Shearing-Strength

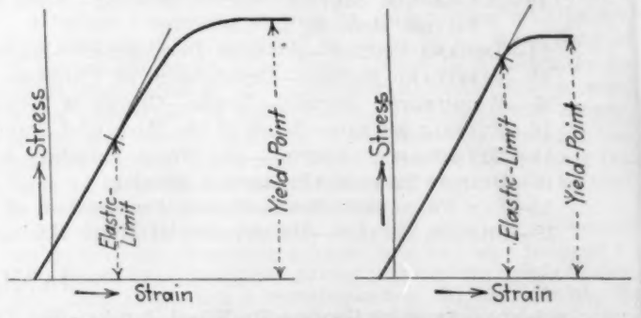
For ductile metals the shearing-strength is best determined by torsion tests. For brittle materials the shearing-strength is not a particularly significant property and no commonly used reliable method of determining it exists. In Professor Moore's opinion, a fairly reliable method for separating brittle metals from ductile metals is to class as brittle those metals whose shearing-strength is greater than their tensile-strength. When parts are made of brittle metals the danger of tension failure is nearly always greater than of shearing failure. For materials having a well-defined grain, wood for example, the shearing-strength along the grain is an important physical property of the material.

The ball-impression test for most metals gives a fairly reliable index of their tensile-strength. In the case of wrought ferrous metals, it also serves as a fair index of the strength under repeated stress. For machine parts that are so small or so irregular in shape that a ball-impression test cannot be made, the scleroscope gives results of the same order of significance, provided it is used by a skilled operator. In Professor Moore's opinion, none of these tests, although designated as hardness tests, has proved its value as an index of cutting hardness or resistance to abrasion.

The significance of notched-bar, Charpy and Izod tests is not at all clearly defined, said Professor Moore. Since the specimen is notched, no accurate computation can be made of the stresses in it; the test results are purely arbitrary, depending almost entirely on the dimensions and shape of the specimen, especially those of the notch. Tests of this class certainly do not give an idea of static strength, neither do they give an idea of the resistance of a metal to repeated stress.

How to Judge a Metal's Resistance to Fatigue

The fatigue test used most commonly today applies cycles of reversed flexural stresses to a rotating cylindrical specimen that is loaded as a beam. First, a specimen is tested under a heavy load and failure occurs after a few thousand revolutions of the testing machine. Further specimens are run with successively diminishing stresses and these show a constantly increasing life. A diagram is plotted using values of stress as ordinates and values of the number of cycles necessary to cause failure as abscissas, giving what is commonly called the *S-N* diagram. After a number of specimens have been tested, a stress is found for which the direction of the *S-N* diagram changes abruptly. This is called the endurance limit or the fatigue limit. Professor



How Internal Strains Affect Physical Characteristics

A Stress-Strain Diagram like the One at the Left Is Characteristic of Steel with High Internal Strains Which, as the Load Is Increased on the Specimen, Causes the Most Stressed Fibers To Yield. A Stress-Strain Diagram like That at the Right Is Characteristic of Steel with Low Internal Strains

Moore considers that the endurance limit seems to be a reliable index of the material's ability to withstand oft-repeated stresses of a given magnitude. Taken alone, the endurance limit is not an index of the resistance of a material to occasional severe over-stress followed by oft-repeated normal stress.

Professor Moore discounted the value of repeated-impact tests made by subjecting a notched specimen to a series of light transverse blows, the specimen being turned 180 deg. between each blow. He said that the test gave arbitrary values. It might be of value for a given material for a given use and with a given design of machine and specimen, but the results would have little significance if any of these factors were varied.

Ductility Tests and Their Significance

Three tests for ductility are in common use; cold-bend tests, measurement of the elongation after tensile fracture and measurement of the reduction of area after fracture. The two latter methods seem to give the best index of ductility for the material in plates, shapes, rods, forgings and steel castings. Some form of cupping test seems to give the best index of ductility for sheet material.

The opinion is often expresed that ductile materials will resist repeated stress better than will brittle materials, even though the latter be stronger statically. Test results do not at all bear out this opinion, said Professor Moore. Brittle hard steel withstands millions of repetitions of stress which would snap ductile wrought iron or soft steel after a few hundred repetitions. Ductility is not a direct measure of strength or of strength under repeated stress. Nevertheless, ductility in a metal is a valuable property. As Professor Moore sees it, the value of ductility is two-fold: first, ductility furnishes insurance against shattering collapse immediately following elastic failure, and, second, if a machine or a structural part is subjected to a few accidental heavy overloads, ductility tends to prevent the formation of minute cracks that under succeeding cycles of normal stress open farther or spread, thus weakening the member and finally causing a fatigue failure. Deep scratches, notches and sharp shoulders cause more danger of failure in machine parts made of brittle material than in parts made of ductile material.

Ordinary formulas of the mechanics of materials neglect completely the scores of localized stresses in ordinary machine parts such as those occurring at the roots of threads, at the roots of keyways, at the edges of holes, at sharp shoulders and at bearing points. These stresses are sometimes from two to five times as great as those computed by formula. Under static loading they are not important for ductile materials, but under repeated loads they are not negligible, even for ductile materials. True, they do less damage to parts made of ductile material than they do to those made of brittle material.

THE SHENANDOAH AND THE ZR-3

Successful Trips Over Land and Water Center Interest on This Type of Aircraft

Experiences of the ZR-3 in crossing the Atlantic Ocean and of the Shenandoah in making her record-breaking trip across the American Continent and back were described by the navigating officer, Lieut.-Com. C. E. Rosendahl, U. S. N., in an informal talk before the Metropolitan Section at its monthly meeting at the Hotel Cumberland, New York City, on Nov. 20.

Several reels of motion pictures gave vivid impressions of the ZR-3 as it left its German home and later circled about New York City, and of the Shenandoah's maneuvers while making landings at the various mooring-masts at Lakehurst, Fort Worth and San Diego and at the floating mast on the steamship Patoka. Views of the terrain traversed on the way West and of the rocky Pacific coast were also exhibited.

W. E. Doerr, of the Goodyear-Zeppelin Co., during the discussion, outlined the development of Zeppelins in Germany, of which he has been so important a factor, stated his views regarding the comparative merits of helium and hydrogen and contrasted the fields of usefulness of the heavier-than-air and the lighter-than-air craft.

The Shenandoah

The Shenandoah, said Lieutenant-Commander Rosendahl, was originally laid down as the ZR-1. The ZR-2 was bought from England but was lost on the Humber. The chief value of ships of this type, he said, is as scouts. So far, they have not done much operating with the fleet but, on the only test made during recent war maneuvers, the Shenandoah had been successful in locating an "enemy" battleship. The principal purpose of the recent trip across the Country was

Schedule of Sections Meetings

DECEMBER

4—Detroit Section—Easy-Riding Meeting—Shock-Absorbing Devices—Leighton Dunning; Springs—David Swinton; Cushions—E. W. Goodwin

9—Pennsylvania Section—Engineering Observations Made In Europe—B. B. Bachman

10—Milwaukee Section—Service Meeting—Some Service Observations—Charles D. Prinz; Educating Service Men—E. L. Consoliver

11—Indiana Section—Aviation Development—Major E. L. Hoffman; Superchargers—Dr. F. A. Moss

15—Cleveland Section—Development of Clutches—Ernest E. Wemp

15—Washington Section—Traffic—George M. Graham

16—Buffalo Section—Work of the Bureau of Standards—Dr. H. C. Dickinson

18—Metropolitan Section—Six-Wheel Vehicles—A. W. S. Herrington and A. F. Masury

18—Detroit Section—Production Meeting

18—San Francisco Group—Modern Development of Medium-Speed Solid-Injection Diesel Engines

19—Chicago Section—Development of Motor Racing Cars and Engines—Fred S. Duesenberg

JANUARY

9—Los Angeles Group—Six-Wheel Trucks—The Difference of Various Types of Construction, Their Effect on the Road and a Mathematical Analysis of Impacts of Six-Wheel Trucks in Comparison with Four-Wheel Trucks

to cater to the demand of the people to see the ship. Its length is 680 ft. The framework is constructed of duralumin, a metal having one-third the weight of steel but having the same tensile-strength as open-hearth steel. Helium gas, with which it is filled, has a lifting power that is about 92 per cent of that of hydrogen. The Shenandoah's capacity is 2,250,000 cu. ft. of gas. Originally, it had six engines, but as scout ships must be provided with radio apparatus, the space occupied by one engine is now used for this purpose. Twenty-two enlisted men compose the crew, but as many as 40 persons have been carried, the additional number being those in course of training. One object of the transcontinental flight was to determine the ability of the airship to operate away from home. When the plan of sending it to the Arctic Region was under discussion three mooring-masts were built, which were used on the recent trip.

The ship sailed from Lakehurst on Oct. 7, arriving at Fort Worth on the 9th. They had counted on at least an even break as regards the wind, but during the trip unfavorable winds were encountered in the ratio of 5 to 1. The actual running time from Lakehurst to Fort Worth was 37 hr.

San Diego was reached by following the railroad lines. At the start the gas bags are 95 per cent filled and, due to expansion of the gas, a certain definite altitude can be maintained. Lift is essential to carry sufficient fuel and cannot be sacrificed for altitude. The higher the ship goes the less will be the lifting power. Obstructions look larger at night. As the trip was made during the period of full moon, good progress could be made at night.

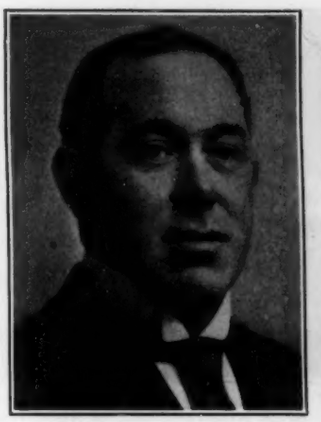
Variable Winds Retard Progress

Winds are variable and follow the mountain sides. They are also affected by the character of the terrain, trees, plowed fields and the like producing up-and-down currents of air. Very slow progress was made through the mountains. If the newspaper story published at the time regarding the narrow escape of the ship from striking a mountain were true, said Lieutenant-Commander Rosendahl, he was not aware of it. They had planned to arrive at San Diego at sunrise. The heat from the sun has the effect of superheating the gas and giving it a false lift. When the ship takes off from a mast it is in a position of balance; when it is light the stern is up. Although the ship is lighter than air, during a large part of the time it operates dynamically, like a heavier-than-air ship.

At Camp Lewis, because of the fog, the location of the mast could not be seen, but the ship was guided to it by radio signals. At San Diego, on the return trip, they encountered a heavy fog. They had been flying at a 1000-ft. elevation. At 1500 ft. the fog was still present but at a slightly higher point they got out of it. The only objects that could be recognized were three radio masts. They went out to sea but soon after, the sun came out again. With it came the condition of superheat. While trying to go down they encountered a stratum of cold air and could not get down without releasing some of the helium gas. On the return trip they started out with a large quantity of fuel but had to throw three fuel tanks overboard. The trip back from Fort Worth to Lakehurst was made by an inland route. The total distance covered on the trip, the longest overland voyage ever made by a ship of this kind, was 9317 miles.

America's Assets

America now has two very valuable things, said W. E. Doerr, in opening the discussion. One is the ship; the second is the experience that has been obtained from it. What has been accomplished is more than merely valuable. America now is farther advanced than is England and this fact is the cause of the recent activity by the English, who have two large ships in course of construction. The performance of the Shenandoah, he said, was pioneer work. It has demonstrated that the ship can go for a very long time without returning to the hangar, has given proof of the value of the mooring-masts and has settled the question of competition between heavier-than-air and lighter-than-air ships. Most persons think the two types are competitors but they



W. E. Doerr

Lieut-Com. C. E. Rosendahl

are not. Their tasks are different and they supplement one another. The airplane must always carry by motive power not only its own weight but that of the fuel, whereas the lighter-than-air ship carries its load by the lifting power of the gas. The airplane must come down to refuel, but the lighter-than-air ship can cover much greater distances before doing so.

Lighter-than-air ships must have terminals, which are expensive. They can keep away from bad weather, go around spots of low pressure and consequently always have a "pushing" wind. The ZR-3 did that on its recent trip across the Atlantic. It first went south, then north, to avoid a low-pressure area of this kind. One thousand to 1200 miles is about the limit of the "hops" of an airplane, but a lighter-than-air ship can cover about 2000 or 3000 miles.

Mail Service

American mail service, he said, was a fine accomplishment. Lighter-than-air ships could not compete over such distances as that from New York City to Chicago, but they could take the mail at the end of such a trip and transport it over the ocean. This development is merely a question of capital. It is pioneer work, but, in his opinion, there is no question about its being made to pay.

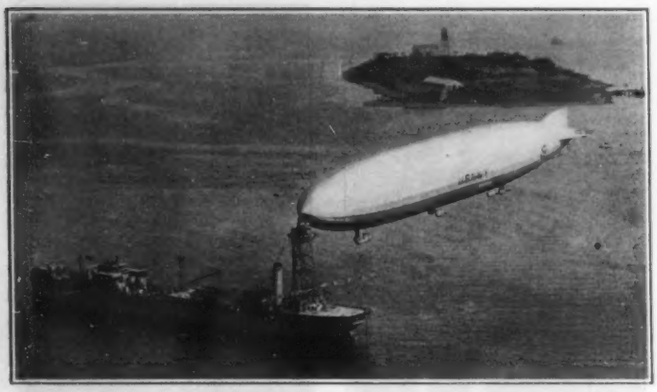
Persons usually think first of passenger transportation, but this is not the most important. It is a question of gas. Helium is expensive. Helium-filled ships must be larger to have the same lifting power as hydrogen-filled ships. It is difficult to tell whether hydrogen or helium should be used. The suggestion has been made that the helium should surround the hydrogen so that only the hydrogen will need to be replenished. The danger of hydrogen, Mr. Doerr said, had been exaggerated; he had made more than 500 trips in hydrogen-filled ships and was still living. If helium only is to be used, the lack of it may retard development.

North and South Flights Recommended

Although the saving in time by transporting mail by airship over the Atlantic would be about 55 hr. from America to Europe and about 70 hr. from Europe to America, he believed that, because of meteorological conditions, a much better plan would be the installing of mail service between North and South America. One line has already been planned between Spain and South America. Ships now take from 14 to 16 days to make that trip, which could be made in an airship in from 4.5 to 6 days.

The Pacific Ocean, he said, was well adapted, meteorologically, to flying. Formerly a naval base had been planned for San Diego, but 4 years had passed and nothing had been done. Now San Diego has a mooring-mast. In his opinion, the Philippine Islands and Hawaii would be fine cruising points.

Charles W. Hall called attention to the improvement in the construction of heavier-than-air ships, saying that in recent work the weight had been reduced to less than one-half that of 2 years ago. The framework weighs only 46½ per cent



THE SHENANDOAH ATTACHED TO THE MOORING-MAST OF THE U. S. S. PATOKA
The Successful Development of These Mooring-Masts Has Greatly Increased the Radius of Action of the Dirigible

of that formerly in use. The ratio of the weights, he said, is about the same as the ratio of the moduli of elasticity. For such parts as spars, light alloys give greater strength. Stresses are balanced off. When airplanes fly upside down, what is an extension member at one time may be a compression member at another. Riveting is the most satisfactory way of joining parts, more so than welding. The rivets can be either driven or squeezed. A small pneumatic hammer, weighing about 4 oz., that strikes about 3000 blows per min., has given satisfactory results, especially on small rivets.

POST-WAR DEVELOPMENT

G. H. Madelung called attention to the fact that the distances covered by airplanes in non-stop flights shortly after the war were from 2000 to 3000 miles. Since that time the ratio of the power to the weight carried has been greatly increased, principally by metal construction. For this the coming of the internally-braced monoplane has been largely responsible. The range of airplanes on non-stop flights is about 800 miles. Non-stop records of 36 hr. that have been established could not be made in regular service.

Replying to a question, Lieutenant-Commander Rosendahl asserted that mooring-masts are only temporary landing-places, for the airship must eventually return to the hangar. An airplane is not brought to a hangar except for repairs and overhauling. Regarding refueling, he said that small airships never carry more fuel than they need. Airships can take on fuel, water, provisions, and the like, when moored to the mast.

ZEPPELINS

Outlining briefly the early development of Zeppelin aircraft, at the request of Chairman C. M. Manly, Mr. Doerr said that during the Civil War, Count Zeppelin lived in this country near what is now Langley Field. He took up his present work when he was 57 years old and was considered crazy. But his first ship flew and had some motion of its own. In 1908, when one of his ships was destroyed the people contributed toward a new one. In that year he began the organization of his company, and the carrying of passengers was also begun. The Deutschland was built in 1910. This was destroyed, but the passengers landed safely. After the ship had landed in a tree, the steward calmly took out his book and began collecting the amounts due him from the passengers. This steward left later when the passengers began ordering beer instead of champagne. Passenger-carrying development increased with the production of three or four ships before the war. During the war, Germany had 88 Zeppelin airships and facilities for making them were so improved that a ship could be turned out every 2 weeks. Some of the ships have risen to a height of 23,000 ft., but even then they are big targets and their chief value is in scouting.

Since the war, two ships have been built for passenger service, one of them being the Bodensee. Reservations for the trips of this ship were booked 2 weeks in advance. The 400-mile trip was made in from 4½ to 6 hr. and saved about 3 days' time. One of the ships is now in Italy, the other in France. The ZR-3 is the last one built. Germany is now allowed to produce ships of only 30,000-cu. m. capacity or less.

In reply to a query regarding attacks from airplanes in war, Lieutenant-Commander Rosendahl remarked that the advantage lay with the airships because they had more stable platforms from which to fire and could continue firing longer. One way to attack them, he said, would be to nose down toward the airship and then step into a parachute.

INSURANCE FEATURES TOPIC AT DAYTON

Design That Affects Rates and Provides Fire, Theft and Collision Resistants

Principal insurable hazards of motor vehicles that can be controlled or reduced by the designing engineer were outlined authoritatively by C. R. Alling, engineer of the casualty department of Underwriters' Laboratories, Inc., Chicago, in his paper, The Automobile from the Insurance Underwriters Viewpoint, that was presented at the Dayton Section meeting held on Nov. 12. He prefaced his remarks by a brief statement of how the laboratories he represents came to be established, and of how they have been developed to their present status.

Insurance and automotive engineers have radically different viewpoints. An insurance engineer must know whether the automobile possesses inherent fire hazards, whether the design is such that the car can be controlled so as to avoid accidents, whether it is built so that it will sustain the minimum damage in the event of a collision and whether the design is such that it can be stolen easily and marketed. An automotive engineer must know that the automobile has good selling qualifications; a good appearance and design features that have to do with its long life, power, riding-quality and ease of control. Insurable automobile hazards are segregated into those of fire, theft, collision, property damage and public liability. Engineering problems having to do with these hazards are as important to the insurance engineer as are the design problems to the automotive engineer.

FIRE HAZARDS

Following a brief resumé of fire insurance rating, Mr. Alling divided inherent automobile fire hazards into those incident to the fuel feed-system, including the fuel tank, the fuel line and the carbureter; to the electrical system; and to the exhaust system. Of the first, although unconfined gasoline can be ignited readily, when in liquid form, by a spark or by flame and, while a gasoline vapor-air mixture is explosive when the range of the mixture is between 1.5 and 6.0 per cent, investigation has shown, contrary to the general impression, that automobile fuel tanks explode rarely, if ever, because it is practically impossible to obtain an explosive mixture of the vapor above the fuel in the tank. Because of the volatility of gasoline under ordinary atmospheric conditions and with the gasoline tank practically always containing a measurable quantity of gasoline, it is almost impossible to obtain an explosive mixture above the liquid level, although a burning mixture is generally present. Due to a careless use of flame at the filling opening or because of static sparks, fires are a natural result but the probability of explosion is remote.

Fuel-pump or vacuum systems of feeding gasoline to the carbureter are preferred by underwriters to a gravity feed, because a leaky carbureter will discharge less gasoline to the garage floor than if it leaks when fed by gravity. Also, with the pressure or vacuum systems, the fuel supply can be located at the rear and, if fire occurs in the engine compartment, the fuel is less likely to become ignited. Recent improvements whereby the intake-air is preheated have reduced to the minimum the hazards due to back-firing in the carbureter; with many present types of air horn, the flame is dissipated before reaching the engine compartment but, since cleaning the engine of oil, grease and gasoline is

so infrequently practised by motorists, a design essential is to obviate sparks and flame at this location. Many other minor factors that aggregate a serious risk must receive consideration if fires due to gasoline leakage are to be eliminated.

Electrical automobile hazards present similar problems to those of electric lighting and power. Overheating and burnouts result from using wire having insufficient current-carrying capacity. Contrary to the general belief, fire danger due to short-circuits or grounds on a 6-volt battery system is *not* negligible; field experience proves it as necessary to employ as good electrical construction as for house wiring. Fused circuits are essential and so are properly protected splices and adequately covered starting, lighting and ignition units.

Exhaust-system hazards include a consideration of the location of the exhaust-line and the muffler with respect to combustible material, the possibility of the occurrence of back-firing that may cause muffler explosions and the attendant fire risk of rupturing the muffler and the ignition of combustible material from the flame in the exhaust. If improperly designed or installed, exhaust heaters add to the fire danger and so do muffler cut-outs, the latter because flame or sparks may ignite combustible material on the vehicle or gasoline on the garage floor.

The Automobile Theft Problem

Thefts of automobiles constitute a major problem of the insurance companies. In addition to other precautions, physical means must be employed to prevent unauthorized automobile usage. At present, the theft-insurance rate is reduced 15 per cent for any automobile lock installed as accessory equipment, and a further preferential of 5 per cent is allowed if such a lock, listed by Underwriters' Laboratories, is installed at the factory as standard equipment.

As the stealing of automobiles for resale became almost a profession, the underwriters' standards of theft resistance were raised and, to ignition-lock devices, were added steering-system and transmission locks. A super-classification of locks was then made to make it necessary that a driver lock his car when leaving it unattended, and the so-called "coincidental lock" is the logical outcome of this demand.

The Coincidental Lock

This lock is arranged so that the driver, in breaking the ignition circuit, places the car in the theft-resisting position; and, when locked, it is impossible to start the engine. The interconnecting of the ignition with the lock is applicable to steering-system, transmission and ignition locks, and the term "coincidental" does not in itself imply a steering-system lock.

Objections to the coincidental lock are principally that (*a*) a car so locked cannot be moved by the fire department, (*b*) it prevents maneuvering a car parked in a public garage and also prevents its removal in case of fire and (*c*) such a lock, of the steering-system type, prevents shutting off the ignition when coasting down a hill and thus increases the accident hazard because of the possible increased speed when the engine operates under such conditions.

Regarding (*a*), Mr. Alling said that many cities have an ordinance requiring unattended cars to be locked, and that a car equipped with this lock can be moved a reasonable distance if necessary. Such an objection really refers to the parking of cars, whether locked or unlocked, and applies to every car.

As to (*b*), the claim is not in accordance with the facts. With the recognized type of coincidental lock, the key can be left in the car. Insurance companies make no conditions respecting the locking of cars in public garages.

Concerning (*c*), Mr. Alling believes the shutting off of the ignition when coasting down a hill to be an undesirable practice. He cited car-builders' instruction-books that advise against opening the ignition circuit under such conditions, and mentioned its other undesirable consequences, such as engine fouling, crankcase-oil dilution, back-firing and possible failure of the muffler.

A second and great problem is to prevent the resale of cars after they have been stolen. A safeguard against resale exists in numbering frames and engine blocks so that the numbers cannot be altered or destroyed without leaving evidence.

Collision Minimization and Prevention

Experience rating governs collision and property-damage insurance-rates, and safeguards to reduce collision possibility will later be reflected in collision-insurance rates. Two classes of safeguard in this respect are those that reduce the probability of accident and those of design that minimize the damage done to cars as a result of accident.

Mr. Alling said that the braking system should be adequate to permit complete control of the car and that, with reference to four-wheel brakes, no question exists but that lessening the stopping distance of a car reduces the danger of collision with objects ahead. He cited the proper distribution of braking effect and the pressure required to operate the brakes as very important factors and remarked on how little attention has been paid to the fact that women have less physical strength available than men for brake operation.

Other features that affect the collision hazard include the design and the location of the brake, the clutch and the accelerator pedals; improperly designed steering-systems; too heavy windshield and frame-supporting sections at the left front end of the body and head-lamps that produce glare. Pedals should provide against foot-slip, and the accelerator pedal should be guarded against accidental operation when the driver uses the service brake quickly. Steering-systems require positive fastenings in securing bolts and rods in the gear linkage, and should be irreversible to increase steering-wheel control on rough roads. Heavy frames in front and glaring lamps interfere with drivers' vision.

Substantial front cross-frame braces reduce radiator and front-end damage, suitably designed bumpers absorb collision impact and minimize its effect on the car and seamless fenders not projecting beyond the tire are less likely to damage and more cheaply replaceable. But Mr. Alling said that collisions will continue to occur, despite all safeguards, and advocates automotive design that will cheapen the cost of repair. From a design standpoint, property-damage and public-liability hazards are synonymous with collision hazards.

150 M.P.H. IN A MOTORBOAT!

Gar Wood Tells Detroit Section That This Speed May Be Reached in the Future

Imagine a transatlantic motorboat race from New York City to London that would be completed inside of 48 hr. The prospect of such a race being held is not entirely fanciful, according to Gar Wood, motorboat enthusiast extraordinary, who addressed the Detroit Section on Nov. 13. Multiple-step hydroplanes powered with six engines and refueled in mid-ocean could do the trick. Mr. Wood told the members many interesting tales of his motorboat racing experiences, beginning back in youthful days when his racing career started aboard a small boat of his father's that was powered with a one-cylinder two-cycle engine.

Photo by Edwin Levick

GAR WOOD

What is termed the V-bottom hull is the type most popular today among builders of racing motorboats, said Mr. Wood. It is easier to build and very much more stable than hulls of the round-bottom type. A V-bottom boat has less tendency to roll and is more seaworthy and much stronger than the

round-bottom boat, if the decks and the bulkheads are properly designed and placed. The sides are almost vertical and the bottom is almost flat. The bottom is made best by running one skin of planking diagonally from either side of the keel to the outer corner pieces, this being tied together by another skin of longitudinal planking. Water-proofed silk or canvas is laid between the two layers to prevent leakage.

Speed-boat hulls must be taken out of the water between races or they will absorb an excessive weight of water. A conventional hull will soak up as much as from 400 to 500 lb. of water. Mr. Wood said that he always removes his boats from the water after each race to prevent swelling of the planking. Sometimes the shape of the hull will change slightly overnight, and this may reduce the speed of the boat 5 m.p.h. To gain a few miles per hour in speed, the hull is sometimes sprung purposely before a race by properly blocking and weighting it. A sag of ½ in. may mean a change in speed of several miles an hour.

Single-Step Hydroplanes Are Fastest

The greatest speed has been attained with hydroplanes of the single-step type. Monoplanes, or hulls built without a step or offset in their bottom surface, have a very bad tendency to hurdle or gallop over the water when running at high speed. This action is present even when racing over smooth water. Mr. Wood said that he can eliminate this tendency in hulls of the single-step type, but he does not know how it can be overcome in the case of the monoplane hulls.

Airplane engines have aided materially in advancing the speed of racing motorboats. Mr. Wood said that, before these were available he had been hindered by the excessive weight of conventional marine engines, even when especially light reciprocating parts were used. His first experiments with a Curtiss airplane engine resulted in getting the propeller speed up to 2400 r.p.m. Next, the Liberty airplane engine was tried and this has proved most satisfactory. It was necessary to adapt the Liberty engine to marine service by fitting it with a flywheel, water-cooled exhaust-manifolds, special water-circulating apparatus, electric starter and other details. Although this engine is run at much lower speeds in airplane service, Mr. Wood has been operating it satisfactorily at speeds as high as 2300 r.p.m. Credit was given the airplane engine by Mr. Wood for the attainment of the present-day high speeds of motorboats.

It has been found desirable to use geared-up propeller drives in recent high-speed motorboats, said Mr. Wood. A two to one ratio of propeller to engine speed has been used with good results. The use of higher propeller speeds makes it possible to decrease the pitch of the blades with a resulting increase in the propeller efficiency. Another advantage is presented in the placing of the engines nearer the stern of the boat, where the machinery is relieved of most of the terrific pounding of the sea that it used to receive when placed forward. Moving the engines aft also gives the boat better balance, reduces its diving tendency in a following sea and improves its seaworthiness.

Boats May Attain Speed of 150 m.p.h.

Motorboat speeds of 150 m.p.h. do not lie beyond the realm of possibility, in Mr. Wood's opinion. He remarked that if the British ever make another challenge for the Harmsworth Trophy, boats will be built which will use four propellers placed in two pairs, one at the rear end of each hydroplane step.

Future progress of the motorboat industry depends largely upon better cooperation between the boat-builders, Mr. Wood intimated. Too much criticism of one another has occurred in the past and too little attention has been paid to standardization. The time is coming when men of broad vision who are favorable to cooperative action and a policy of standardization will enter the motorboat industry and then it will be extended. Such extension will not reach the proportions of the automobile industry, but it will make the motorboat available to many more people than are able to enjoy it today.

DILUTION NEEDED FOR EASY STARTING

Chicago Meeting on Winter Operation Presents a New Angle of Dilution Problem

Assuredly, engineering is an art of compromise! With engineering investigators searching diligently for means to prevent the dilution of crankcase oil by unburned motor fuel, it now develops that a certain degree of dilution is highly desirable and almost essential for satisfactory winter operation of automotive engines. Clean oil, undiluted, becomes so viscous at temperatures around and below the zero mark on the fahrenheit scale that conventional starting-motors and batteries are incapable of turning the engine with sufficient rapidity to start it. This was the outstanding point recorded at the timely and valuable meeting of the Chicago Section on Nov. 21, which was devoted to problems of cold-weather operation. Papers were read by O. C. Berry, chief engineer of the Wheeler-Schebler Carburetor Co., and J. H. Hunt, of the General Motors Research Corporation. As reported in the following paragraphs, carbureters, starting primers, hot-spot design, heated crankcases, thermostatic temperature control, starting motors, lubrication and air-cleaners were some of the main details that received attention. Several entirely new views were presented.

Mr. Berry introduced his talk by showing a typical curve of gasoline consumption for a car during an entire year. This indicated that the greatest fuel economy is attained during the summer months and the least is in the winter months. In a large part, this is due to the excessive amount of fuel needed in extremely cold weather to insure the presence of enough volatile constituents in the cylinder to form a combustible mixture for starting. Mr. Berry said that 14 to 15 times the fuel required for ordinary running is needed to start an engine at — 10 deg. fahr. Thus it appears that approximately 1 lb. of fuel is needed for every pound of air!

Cranking Speed Should Not Be Less Than 60 r.p.m.

Carbureters cannot be expected to serve their function as metering and vaporizing devices below an engine speed of 60 r.p.m. That is to say, engine starting is problematical when the starting-motor cranks at lower speeds than this. Carbureter engineers prefer a speed of 100 r.p.m. Granted that an adequate cranking speed is provided, present-day carbureters will start an engine at temperatures as low as — 10 deg. fahr. without the application of external heat. Below that temperature, some means of preheating must be provided.

Once started, it is extremely important from the driver's standpoint that the warming-up period of an engine be made as short as possible. Mr. Berry said that he knew of no device or method that insures the smooth running of an engine during this warming-up period; erratic running will persist until the manifold has reached the temperature required to volatilize a major part of the liquid fuel entering the cylinder. Curves shown by Mr. Berry indicated the temperature that an iron plate must reach to effect rapid volatilization of commercial gasoline that is passing over it. Comparison of this temperature with that prevailing in the exhaust of an engine showed that sufficient heat is available in the latter to volatilize liquid gasoline readily. Since the desirable temperature for rapid volatilization is well above the boiling-point of water, it is apparent that water-jacketed hot-spots are of little value for reducing the warming-up period. High temperatures must be attained at one spot and these as soon as possible.

Mr. Berry's Conception of the Ideal Hot-Spot

To secure the ideal condition for quick warming-up of the engine, Mr. Berry recommended that the hot-spot be relatively small and the wall of the manifold very thin in the region of the spot, so as to keep its heat capacity low. This hot-spot should be located on the vertical manifold pipe, just above the carbureter. Experiments have shown that the greatest accumulation of liquid fuel occurs on the walls of the manifold at this spot, which is just above the throttle valve. To apply the heat here prevents the settling of the

fuel and avoids irregular running of the engine. Using this type of hot-spot, Mr. Berry has found it possible to have a car perform at the end of a 0.4-mile run just as it would if fully warmed-up.

Reference to the matter of some dilution being necessary as an aid to easy starting came when Mr. Berry spoke of having made certain tests in the "cold-room" with an engine having its crankcase filled with fresh oil. It was next to impossible to turn the engine under these conditions and after a short series of starts it was in such bad mechanical condition that it was torn-down and inspected. The inspection revealed that the pistons and the cylinder-walls were scored and the bearings badly worn. This rapid wear could only be attributed to inadequate lubrication, resulting from the failure of the pressure oiling-system to feed the extremely viscous oil to the bearings from which it was supposed to be thrown upon the cylinder-walls and the pistons. Before undertaking further low-temperature tests in the cold-room, it was decided to dilute the lubricating oil with kerosene. This experience led Mr. Berry to wonder whether devices designed to remove the diluent from the crankcase oil, or to prevent its accumulation, will not cause trouble in cold weather by keeping the oil so viscous as to impede starting and interfere with proper lubrication for a considerable period after each start is made.

Following his recommendations further, Mr. Berry said that some means should be provided for controlling the jacket-water temperature thermostatically so that it will rise rapidly after starting, thus avoiding excessive dilution of the oil and the condensation of water in the crankcase. It is well to cover exposed oil-pans that are cast with integral air-cooling fins so that they will be protected from the cold winter blasts. Otherwise, the chilled oil will be too viscous to lubricate properly and dilution will be aggravated. Air-cleaners should be fitted to prevent the excessive wear that results from a combination of road dirt and diluted oil. Some positive means should be provided for the lubrication of the pistons and the cylinder-walls during the warming-up period, in Mr. Berry's opinion.

Dilution Aids Starting in Cold Weather

In discussing troubles encountered with the electrical system during cold weather, J. H. Hunt agreed with Mr. Berry that a certain degree of dilution is desirable in winter, stating that starters of conventional capacity cannot function satisfactorily at low temperatures unless the so-called winter oils are diluted about 15 per cent. Starting-motors of larger torque-capacity can be built by the electrical engineer, but the motor-car manufacturers do not appear willing to pay the increased cost that this would entail. Mr. Hunt said that it is his practice to dilute fresh oil with kerosene before using it in engines under test in a cold-room. He sounded a warning against putting fresh oil in an engine just before putting a car away for the night in a cold garage. Starting difficulties will certainly present themselves on the morrow.

Mr. Hunt said that starting troubles are often attributed wrongly to the ignition system. Before blaming the ignition system, it is best to try starting a balky engine with an independent and properly charged storage-battery furnishing the ignition current. Not infrequently it is found that the engine refuses to start even under these conditions and it is clear that the trouble lies with the carburetion in such a case.

With the number of crankshaft bearings on the increase, it is well that aluminum is seldom used for crankcases and that bearings are not hand-fitted to close clearances, said Mr. Hunt. He encountered one instance where the aluminum crankcase contracted due to the low temperature until it held the seven-bearing crankshaft in a vise-like grip that could not be broken by the most powerful starting-motor.

Balance of Battery and Starting-Motor

In Mr. Hunt's opinion, not enough attention has been given to the proper balance of battery and starting-motor characteristics under cold-weather conditions. A nicety of balance can be achieved between starting-motor torque and speed in relation to the discharge rate of the battery provided the electrical engineer is consulted. Many times such a balance is provided in the original design only to be destroyed by subsequent changes in the battery or the starting motor to reduce the cost of these units.

O. C. Berry

J. H. Hunt

One unique point was presented by Mr. Hunt. This related to the possibility of the heat under the bonnet of a car fitted with radiator cover, thermostats and other paraphernalia volatilizing the very light ends of the fuel in the carbureter during the cooling-off period, so that these will not be available to aid in making the next start. Such a state of affairs will delay the start until sufficient fresh fuel has been drawn from the vacuum tank to furnish the volatile ends so essential to the formation of an explosive mixture under cold conditions. This indicates the importance of insulating the carbureter from hot-spots on the manifold so that residual heat cannot flow from them to the carbureter and evaporate the all-essential light ends of the fuel in the bowl.

Some forms of electric priming or vaporizing device are very satisfactory for promoting easy starting, said Mr. Hunt. He spoke particularly of the devices used on Lincoln and Franklin cars as being efficient.

Choking Engine Prior to a Stop Discouraged

The discussion at the meeting was very lively regarding the desirability of choking an engine with the ignition off just as it is being shut-down. Some thought this might aid starting by leaving an explosive mixture in the cylinder and by thinning the oil between the cylinder-wall and the pistons. The preponderance of opinion was opposed to the practice, largely because it aggravates dilution and destroys rather than benefits the lubrication between the cylinder-wall and the piston upon starting. C. P. Grimes said that the Franklin electric primer has reduced by half the current needed to make a start under conditions of extreme cold. He suggested that the minimum speed for cranking be determined by finding the slowest speed at which the engine can be turned and still have the flywheel act to smooth out the variations in the torque. This was found to be 28 r.p.m. in the case of the Franklin engine. Mr. Grimes found it necessary to employ from 5 to 10-per cent dilution of the crankcase oil when making cold-room tests. He tried to heat the undiluted oil electrically to lower its viscosity, but the current demanded for the task was too great and he fell back on the dilution practice. His experience has shown him that from 12 to 15 min. running after a cold start is usually needed before any lubricant begins to reach the cylinder-walls and the pistons.

M. E. Chandler remarked that some accessible means should be provided on cars to enable the driver to control the functioning of the hot-spot. In most cases it requires lifting the bonnet, and performing a wrench or screw driver operation to adjust this heat control. He intimated that a dash control should be provided and that this might properly be combined with the choke control so that the hot-spot will be "all on" when the choke is out and shut-off when the choke valve is open as in the running position.

THE FLOW OF HEAT IN PISTONS

Purdue University Research Results Presented at Indiana Section Meeting

H. A. HUEBOTTER

Results of an extensive research that has been conducted at the Engineering Experiment Station of Purdue University, to determine the characteristics of heat flow in pistons were presented before the November meeting of the Indiana Section by H. A. Huebotter. In general, the conclusions reached have been that a piston-head of uniform thickness is a slightly better thermal conductor than either a tapered or a parabolic section of equal weight. Also, a tapered barrel section is greatly superior to a uniform section as a dissipator of heat. Laboratory tests conducted with gray-iron pistons gave the following results: (*a*) Between 60 and 85 per cent of the heat lost by the piston escapes through the ring belt and (*b*) the ring belt is only 60 per cent as efficient as a plain barrel in transferring heat to the cylinder-wall. The research was started with the object of finding the piston form that would give the lowest head temperature with the minimum of weight. Only cast-iron pistons of the unribbed type have been studied to date. The work is to be extended to include deeply ribbed heads.

In view of the low heat-dissipating property of the ring belt, Mr. Huebotter felt convinced that a broad land in contact with the cylinder at the head end of the barrel would be of material assistance in cooling the piston. By reason of this better cooling, it should not be necessary to provide the large clearance usually given to the top land in current designs, although the determination of the required clearance is admittedly a delicate task. Such a land would also help support the piston and permit the use of a shorter barrel.

Improvement in the thermal contact between the rings and the piston barrel will assist in lowering the piston temperature, said Mr. Huebotter. In gray-iron pistons, a close-grained iron in which the graphite is finely divided and uniformly distributed should be used because of its relatively high thermal conductivity.

The investigation of piston temperatures was made in both a mathematical and an experimental way. The practical tests were conducted in the apparatus illustrated on this page. A 4½-in. piston was mounted in a single inverted automobile engine cylinder and its head was heated by a current of hot gas. Cooling was effected by the conventional water-jacketed cylinder-wall. The heating apparatus consisted of a gas burner burning gas from the city mains. This burner was equipped with a stack tall enough to insure complete combustion of the gas before it reached the piston-head. The stack entered the cylinder through an opening in the head and cleared the piston by 2 in. The combustion temperature was held uniform by controlling the flow of gas at a predetermined rate. The air supply was controlled so that the highest temperature would be reached at the center of the piston-head.

Tests were made with the piston-rings in place and with a liberal supply of lubricating oil between the piston and the cylinder. One side of the piston was held against the cylinder to approximate the operating conditions in the engine, although little difference was observed between the temperatures on the contact side and those on the free side. The temperatures were measured with thermocouples placed at suitable points in the piston and the cylinder.

APPARATUS USED IN THE INVESTIGATION OF PISTON TEMPERATURES
The Piston, Which Had a Diameter of 4½ In., Was Mounted in an Inverted Cylinder, Was Heated at the Head by a Current of Hot Gas and Cooled at the Barrel with the Water-Jacketed Cylinder-Wall

AIR-CLEANERS ADVOCATED

Dollinger Tells Washington Section How To Prolong Engine Life with Cleaners

Basing his discussion upon the thesis that a perfectly lubricated machine never wears out, L. L. Dollinger, of the Staynew Air Filter Co., presented an interesting analysis of the air-filter problem as it applies to automobile engines before the Washington Section on Nov. 14.

In view of the fact that over 9000-gal. of air normally pass through an automobile engine, for each gallon of gasoline used, it is very desirable that this air be as free as possible from dust and other abrasives that may enter to cause unnecessary wear. In instances cited by Mr. Dollinger, the wear on pistons, cylinders and piston-rings was reduced more than 75 per cent by the use of a suitable filter. In a laboratory test of two new truck engines, it was found that the wear on the engine using filtered air was only one-eighth as great on the cylinder walls, one-seventh as great on the pistons, one-sixth as great on the upper piston-rings and one-sixteenth as great on the second and lower rings and the grooves as was the case when unfiltered air was used. Other examples were given to show the advantages of air-filters.

The speaker stated that a cleaner should not be judged by the percentage of dust removed but rather by the percentage that it permits to pass into the engine. An efficiency of 98 per cent, for example, allows twice as much abrasive matter to enter as would be the case with an efficiency of 99 per cent. It is highly desirable that the filter be equally efficient at all engine speeds. Otherwise considerable dirt may be accumulated during the idling periods.

Mr. Dollinger concluded his remarks with the observation that engines will operate from three to five times as many miles before overhauling is necessary and from two to three times as many miles before grinding valves and cleaning carbon are required if an efficient air-cleaner is employed.

(*Concluded on p.* 500)

TENTATIVE STANDARDIZATION WORK

Criticism of all tentative reports should be sent to the Standards Committee in care of the Society

UNDERWRITERS TO APPROVE S.A.E. CABLE

Subcommittee Drawing Up Specifications for a Suitable Corona Test

A decided difference of opinion was evidenced at the meeting of the Subdivision on Insulated Wire and Cable, held in New York City on Nov. 10, with regard to the corona test for high-tension cable. The S. A. E. Standard at the present time does not require such an electrical test. The specifications recently proposed by the Underwriters' Laboratories require 10 turns of cable around a 1-in. arbor to stand, for a period of 25 min., a current from a magneto with a spark-gap of 6 mm. (0.236 in.). Several members of the Subdivision believe that such tests cannot be duplicated and that a transformer test is preferable. It was therefore decided to refer the question to a Subcommittee for further study. Chairman Andrew appointed E. M. Pierson, of Dodge Bros., as chairman; G. O. Becker, S. R. Dresser, W. S. Haggott and B. M. Smarr.

As a result of careful analysis of the strandings specified in the S. A. E. Standard and in the Underwriters' Laboratories' specifications, it was decided to eliminate the No. 2 cable and to include a No. 4 cable with 49 strands of No. 21 wire in the S. A. E. Standard. The Underwriters' Laboratories agreed to include all the S. A. E. Standard sizes that had been omitted from its specifications. Several other omissions and changes that were suggested by members were satisfactory to the Underwriters' Laboratories.

It was also brought out that the S. A. E. Standard requires a minimum wall-thickness of rubber for No. 16 cable of 0.022 in., as against 0.031 in. specified by the Underwriters' Laboratories. Although it was recognized that the wall-thickness is of no great protection against mechanical injury, it was pointed out that this dimension was governed by the outside diameter of braided cable intended for use in conduit. At the suggestion of Mr. Small, this dimension was changed to 0.027 in. with tolerances of plus or minus 0.005 in. The same tolerances were also applied to the other S. A. E. Standard wall-thicknesses.

It was pointed out that many accessories are now sold with cable of inadequate cross-sectional area. It was understood that the Underwriters' Laboratories cannot control this condition, except when accessories are submitted to it for approval.

With reference to the testing of high and low-tension cable, it was decided to include the Gier test in the S. A. E. Standard as an alternative test to the physical tests specified. The S. A. E. physical tests are to be included in the Underwriters' Laboratories' specifications as an alternative test to the Gier test.

The Subdivision members present at the meeting were F. W. Andrew, chairman; Azel Ames, of the Kerite Insulated Wire & Cable Co.; C. J. Bopp, of the Packard Motor Car Co.; H. B. Burley, of the Boston Insulated Wire & Cable Co.; S. R. Dresser, of the Whitney Blake Co.; W. S. Haggott, of the Packard Electric Co.; C. F. Hood, of the American Steel & Wire Co.; F. C. Kroeger, of the Remy Electric Co.; N. B. Parsons, of the Belden Mfg. Co.; D. M. Pierson, of Dodge Bros.; A. R. Small, of the Underwriters' Laboratories, and B. M. Smarr, of the General Motors Corporation. The Subdivision members not present at the meeting are G. A. Black, of the Detroit Insulated Wire Co.; G. A. Delaney, of the Paige-Detroit Motor Car Co.; L. S. Horner, of the Acme Wire Co.; T. L. Lee, of the North East Electric Co.; M. E. Toepel, of the International Motor Co.; G. L. Wanamaker, of the National Metal Molding Co., and C. H. Williams, of the Studebaker Corporation of America. T. L. Lee was represented by R. G. Thompson. Others attending the meeting were G. O. Becker, of the Underwriters' Laboratories; James Lynah, of the General Motors Corporation; J. S. Marvin, of the National Automobile Chamber of Commerce, and R. S. Burnett and C. E. Heywood of the Society's Standards Department.

INSULATED CABLE SUBDIVISION MEMBERS ATTENDING MEETING
From Left to Right They Are W. S. Haggott, F. W. Andrew, C. J. Bopp, A. R. Small, S. R. Dresser, G. O. Becker, R. G. Thompson, D. M. Pierson, F. C. Kroeger, B. M. Smarr, N. B. Parsons and C. F. Hood

LIMA CONFERENCE BEGINS DEC. 23

Representatives of 21 Republics to Be at Standardization Conference

At the call of the Pan-American Union, made at the request of the Fifth International Conference of American States which met at Santiago, Chile, in 1923, a conference on standardization will be held at Lima, Peru, beginning Dec. 23. Twenty-one republics will be represented. The Peruvian Government is acting as host for this conference. Sixty technical and trade organizations in this Country have been invited to be represented at the conference. Invitations have also been sent to similar organizations in other countries.

The purpose of the conference is to study the possibilities of developing inter-American and international standards for raw and finished material, as well as standardized classifications and nomenclature and to make recommendations with regard to the steps to be taken by the States looking toward the development of these objectives. No attempt will be made to adopt actual standards at this meeting, but it is confidently believed that a substantial basis for inter-American standardization can be laid, first, through the development and encouragement of standardization work in the various States and, second, through the designation of

some organization that will act as a central agency for the development of inter-American standardization.

The American Engineering Standards Committee, through an Advisory Committee recently appointed, is cooperating with the Pan-American Union in obtaining adequate representation of American industries. E. A. Johnston, chairman of the Society's Standards Committee and director of engineering of the International Harvester Co., is a member of this committee.

The Peruvian Government has not yet published the final agenda. The Advisory Committee is, however, engaged in getting papers together for the Conference. These will deal not only with the broad principles of standardization, both national and international, but with practical economic conditions. General Manager Coker F. Clarkson has written a comprehensive paper covering the history of the Society's standardization work, which will be presented at the conference. K. K. Hoagg is attending the conference as the official representative of the Society.

MOTORCOACH REGULATIONS PROPOSED

Are Intended to Serve as Basis for Future Municipal Regulations

G. A. Green

At an important meeting of the Society's Motorcoach Committee, held in New York City on Nov. 7, the regulations proposed for the State of New Jersey Board of Public Utility Commissioners were discussed with representatives of the American Electric Railway Association and with traffic supervisors of several New Jersey cities. As a result of the discussion of the proposed regulations, the Motorcoach Committee drew up a general recommendation covering specifications that might well serve as a basis for municipal regulations.

An abstract of the discussion of the more important points in the proposed New Jersey Regulations follows, together with the Motorcoach Specifications proposed by the Motorcoach Committee as a basis for municipal codes.

Discussion of New Jersey Regulations

Body Specifications—It was stated that the streets in Jersey City, Newark and various New Jersey towns make it desirable to restrict body lengths to 21 ft. The Committee felt that the specification for body lengths should be 24 ft., to permit using motorcoaches of greater capacity in localities that might desire them.

Window-Guards—It was felt that particular types of window-guard or dimensions therefor should not be specified as other adequate methods of protection might be developed, such as drop-windows extending from 6 to 8 in. above the body belt-line.

Partition Behind Driver—It was stated that a partition behind the driver introduces an element of danger in that the passenger may be thrown through the partition if the motorcoach stops suddenly. It was understood that the purpose of the partition is to prevent passengers from talking to the driver, but it was felt it would not necessarily accomplish this purpose. It was suggested that, if any partition is specified, a curtain should be used that would also eliminate the reflection of the interior lights on the windshield. Partitions can be readily built in for communities desiring them.

Grab-Handles—It was felt that the question as to whether or not grab-handles should be installed should be left to the manufacturer and the purchaser, because in many communities operating motorcoaches standing passengers are not allowed. Where such arrangements are desired, the motorcoach manufacturers can readily provide handrails, straps or handles on the backs of seats.

Heating System—As motorcoaches purchased by many communities, such as those along the Gulf Coast, do not require heating systems, it was decided to make their installation optional.

Gasoline Tank—With regard to the location of the gasoline tank, it was considered dangerous to place the tank outside the coach body as specified in the proposed New Jersey Specifications, because of the general tendency to lower the floor level as much as possible. It was felt that locating the tank inside the body should be permitted, provided it is completely separated from the passenger space and has the filler, vent and drainage of the compartment in which it is placed on the outside.

Foot-Boards—It was stated that it is difficult to tell at this time what material will be used for footboards in the future and that no restrictions, other than that they should be of fireproof construction, should be imposed.

Seating Arrangement—Inasmuch as seating arrangements are governed entirely by design and local requirements, it was decided that no definite arrangements should be included.

Fire-Extinguishers—It was considered advisable to require that fire-extinguishers be exposed to view at all times.

Stop-Signal Systems—It was felt that regulations should not permit signal systems of the push-button type only, as the cord system, and possibly other systems, will be more suitable or desirable in many installations.

Destination and Route Signs—The requirement that coaches carry a destination sign on the right front panel was considered undesirable, it being stated that this would complicate design and production problems and add materially to the cost of the vehicle.

Overhang of Body—Considerable objection was raised to the overhang requirements of the maximum of 42 in. and the minimum of 38 in. overhang on a 15-ft. body and the maximum of 72 in. overhang on a 21-ft. body, as measured to the center-line of the rear axle. The object of these dimensions, it was explained, was to prevent the installation of bodies on chassis with practically a 50-per cent overhang. Chairman Green suggested that, if any such regulation is recommended at all, it should be expressed in terms of the proportion of the maximum overhang to the total vehicle length. The proportion of 7 to 24, adopted by Scotland Yard in England, which seems to have worked out satisfactorily, was recommended.

Chassis Frame—It was felt that frame dimensions are entirely a matter of design, for which the vehicle manufacturer must take all responsibility, and should not be specified. The reason for including them in the proposed New Jersey Regulations was largely that some frames had broken.

Distance That Body Should Extend beyond the Chassis—It was stated that it is not always possible to have the chassis frame extend the full length of the body and to the end of the body sills, but that the manufacturers always make adequate provision for this feature of construction. It was therefore decided to omit this item as being a matter of design for which the vehicle manufacturers should be responsible.

Radius-Rods—It was stated that the proposed New Jersey specifications call for radius-rods because in-

stances have occurred of rear springs breaking and motorcoaches running wild down-hill. As it was the general opinion that radius-rods are going out of use, that to require their use would add to the weight, the cost, the number of parts and the points of wear and noise on motorcoaches and that the danger involved is being eliminated by the use of better springs and general design, it was decided to eliminate this item.

Tires.—It was felt that the coach manufacturers should not be limited as to the types of tire to be used, as it is not known what developments may be made in the future. Chairman Green cited developments of a new nature, such as a combination of solid and pneumatic tires. It was stated that solid tires are becoming known as "cushion tires" and are being so branded; that some tires with substitutes for air have given promising results; that solid tires can be operated at medium speeds at about one-third the cost of pneumatics, but that they cannot be used for high-speed work. It was decided to recommend omitting this requirement because of the many items, such as weight distribution and spring-suspension, that influence the selection of the type of tire used.

Wheel-Housing—It was explained that the requirement covering the design of the wheel-housing had been included in the proposed New Jersey regulations because of the accidental bursting of pneumatic tires, resulting in injury to passengers. It was felt that this is largely a matter of design, but that a broad provision could be included in the proposed regulations to cover this matter from the safety standpoint.

Motorcoach Specifications

These recommendations are submitted by the Motorcoach Committee to the Society as general recommendations influencing automotive design to serve as a basis for regulations that may be enacted in various States and communities by legislatures or commissions. It is intended also that these recommendations shall be submitted to the State of New Jersey Board of Public Utility Commissioners for consideration in connection with the adoption of regulations for the State of New Jersey.

The following general specifications are intended to apply to only single-deck city-service types of motorcoach.

(1) *Body Specification.*—The maximum overall length of body, measured from the rear of the dash to the extreme rear of the body, shall be 24 ft. The maximum body-width shall be 8 ft., and the minimum inside clearance height above the floor proper, measured at the longitudinal center-line, shall be 6 ft. 2 in. When a ramp construction is used the minimum inside clearance height over the ramp shall be 5 ft. 10 in.

(2) *Window-Guards.*—Suitable protection shall be provided to prevent seated passengers from inadvertently extending their arms or heads through open windows

(3) *Guard-Rail.*—Motorcoaches shall be equipped with suitable guard-rails to prevent passengers from obstructing the view of the driver

(4) *Width of Door.*—The entrance and exit door of motorcoaches shall have a minimum clear width of 24 in.

(5) *Emergency Door.*—Motorcoaches shall be provided with an emergency door located either at the rear of the left side or in the center of the back. The door shall have a minimum clear width of 18 in. and extend from the floor to the upper belt-panel

(6) *Panel.*—The construction of the front end of motorcoach bodies shall be such as to afford the driver an unobstructed vision to the right and left. The construction of the window at the left of the driver shall be such that it may be readily opened for hand-signaling purposes

(7) *Handles.*—Rails or grab-handles must be located inside the vestibule and shall be securely fastened

(8) *Ventilators.*—Motorcoaches shall be equipped with ventilators of a suitable type to assure proper ventilation

(9) *Heating.*—An adequate heating system shall be installed when required

(10) *Gasoline Tanks.*—When the gasoline tank is installed inside of the body, it shall be filled and vented from the outside of the body and shall be completely enclosed inside the body to separate it from the passenger space

(11) *Mirrors.*—All motorcoaches shall be provided with an inside and an outside mirror

(12) *Foot-Boards.*—The front foot-boards shall be constructed of fireproof material

(13) *Fire-Extinguisher.*—All motorcoaches shall be equipped with at least one fire-extinguisher, which shall be maintained in proper condition and exposed to view at all times

(14) *Inside Lights.*—The interior lighting shall be at least 5 rated cp. per seat passenger capacity

(15) *Wiring.*—The minimum size of wire from the battery and the generator to the point of lighting distribution shall be No. 8 A.w.g. stranded. For the interior distribution system of lighting, two lamp circuits in parallel are recommended, for which the minimum size of wire shall be No. 12 A.w.g. stranded, or the equivalent. When more than two lamp circuits are used, the minimum wire-size shall be No. 14 A.w.g. stranded, or the equivalent. All terminal connections shall be soldered and all splices shall be soldered and taped

(16) *Switch.*—All motorcoaches shall be equipped with a switch of ample capacity

(17) *Stop Signal System.*—Suitable signaling devices shall be installed within easy reach of all passengers

(18) *Stop-Lights.*—All motorcoaches shall be equipped with a stop-light

(19) *Destination and Route Signs.*—A route sign shall be located over the windshield on all motorcoaches and so placed and illuminated that it may be read day or night from at least 100 ft. ahead of the vehicle. It must not interfere with the driver's vision or produce an annoying glare

(20) *Overhang of Body.*—The maximum rear overhang of the motorcoach body beyond the center-line of the rear-axle shall be 7/24 of the overall length of the chassis

(21) *Height of Chassis Frame.*—The maximum height of the frame, measured from the ground level to the top of the frame, without pay-load, shall be 35 in.

(22) *Bumper.*—The rear bumper shall extend at least 4 in. beyond the rearmost point of the body and shall be attached to the chassis frame

(23) *Brakes.*—All motorcoaches shall be equipped with not less than two sets of brakes, one operated by a hand-lever and the other by a pedal. Each set of brakes shall be capable of holding the vehicle when it is fully loaded and on a 15-per cent grade

(24) *Wheel-Housing.*—The construction of rear wheel-housings shall be such that no damage can result from bursting tires. The construction of the fenders shall be such that no undue accumulation of dirt or foreign matter can be deposited on the body

(25) *Exhaust.*—The exhaust-pipe shall extend to the extreme rear of the vehicle. The rear windows in the body shall be fixed, to keep out exhaust gas

The Motorcoach Committee members present at the meeting on Nov. 7 were G. A. Green, of the Yellow Coach Mfg. Co., chairman; D. C. Fenner, of the National Automobile Chamber of Commerce; R. E. Fielder, of the Fifth Avenue Coach Co.; G. E. A. Hallett, of the General Motors Research Corporation; A. F. Masury, of the International Motor Co., and A. J. Scaife, of the White Motor Co. Representatives of the American Electric Railway Association present were W. S. Adams, of the J. G. Brill Co., and A. T. Clark, of the United Railways & Electric Co. of Baltimore. The New Jersey Board of Public Utility Commissioners were repre-

sented by George W. Tracy, Leo F. Conlon, F. J. Daly and H. C. Eddy. Others present were Charles Froesch, of the International Motor Co.; T. A. Aspell, of the B. F. Goodrich Co.; W. P. Kennedy, of the Kennedy Engineering Corporation; O. P. Liebreich, of the American National Omnibus Co., and Standards Manager R. S. Burnett.

The only members of the Motorcoach Committee who were not present at this meeting were L. E. Holman, of the Fageol Motors Co.; E. A. Johnston, of the International Harvester Co., and E. W. Templin, of the Six Wheel Co.

During the discussion of the proposed New Jersey specifications, Chairman Green stated that the motorcoach industry is not sufficiently stabilized to attempt standardization at this time, but that it is desirable to establish broad, unrestricted specifications that will guide motorcoach development along proper channels, minimize the introduction of novel and untried features of construction and equipment that would not be of permanent value and serve as a basis for specifications in States finding it desirable to regulate motorcoach operation.

It was thought that any regulations adopted by municipal authorities, particularly in New Jersey, should not embody detailed restrictions because such regulations will probably be followed by other communities in which requirements for motorcoach construction and operation would necessarily be different. It was felt that in cases such as this, undesirable and unnecessary restrictions and difficulties would be placed on the motorcoach manufacturers.

The Motorcoach Committee was appointed by the Council in November, 1923, with the intention that it would serve as a steering committee until it was found desirable to appoint a regular Motorcoach Division of the Standards Committee. A meeting was held in March at Pittsburgh with the Equipment Subcommittee of the American Electric Railway Association, at which nomenclature of motorcoach types was recommended. As the result of this meeting, a survey of the single-deck motorcoach practice was made. This was published in the September issue of THE JOURNAL, p. 186. Another meeting with the American Electric Railway Association's Equipment Subcommittee was held at Atlantic City in October.

With reference to the requirements for inside lights, wiring, generators and switches covered in the New Jersey Regulations, a special Subcommittee, appointed to consider the specifications, met in Cleveland on Nov. 19, and as a result the requirements for inside lights, wiring and switches incorporated in the proposed regulations were adopted. The Subcommittee did not favor including any generator requirements and this item was therefore not included.

A 3-DEG. TILT FAVORED

Recent Tests Indicate Glare Is Practically Eliminated at This Angle

Interesting tests were made by the Motor-Vehicle Lighting Committee of the Illuminating Engineering Society on the night of Nov. 14 near White Plains, N. Y., to determine the most desirable angle of inclination of head-lamp beams to avoid glare. The present S.A.E. Recommended Practice for Head-Lamp Illumination, which is based on joint work of the Illuminating Engineering Society Committee and the Lighting Division of the Standards Committee, is entirely satisfactory for normal conditions. It is known, however, that it is desirable to either dim or tilt the headlights when passing other vehicles, especially on curves and the crest of hills. The tests were therefore made to determine just what angle would avoid glare under the worst conditions.

The tests were made with the new test-car belonging to the National Lamp Works at Nela Park, Cleveland, which was driven to the Illuminating Engineering Society's meeting by H. H. Magdsick and W. C. Brown. The Nela Park test-car was equipped with four head-lamps so mounted and wired that it was possible to obtain two headlight beams complying with the present legal requirements or with 2, 3 or 4-deg. inclination with the car loaded. The observations made to determine what degree of tilt is most satisfactory were made by men riding in a car preceding the test car over a stretch of roadway that had been previously selected because of its bad hills and curves. The observations indicated that 3 deg. of tilt resulted in only momentary glare as the car was passing over the crest of a hill, whereas with 2 deg. of tilt the glare period was still troublesome. Observations were also made with another car, adjusted to give legal illumination, passing the test car in the opposite direction at dangerous points in the road. Rough road conditions were simulated by jouncing the car. Three degrees of tilt was found satisfactory in all cases.

CAR USED TO DETERMINE WHAT DEGREE OF TILT WOULD AVOID GLARE
The Equipment Consists of Four Head-Lamps So Mounted and Wired That It Was Possible To Obtain Two Headlight Beams Complying With the Present Legal Requirements or With 2, 3 or 4-Deg. Inclination With the Car Loaded

Further tests were made to determine the effect of deep and of shallow road-illumination with the 3-deg. tilt. It was found that no real difference was noticeable with these two types of illumination, it being possible to travel with a fair degree of security at 40 m.p.h.

The members of the Motor-Vehicle Lighting Committee of the Illuminating Engineering Society present were W. F. Little, of the Electrical Testing Laboratories, secretary; E. C. Crittenden, of the Bureau of Standards; C. E. Godley, of the Edmunds & Jones Corporation; L. C. Porter, of the Edison Lamp Works; A. W. Devine, illuminating engineer of the Commonwealth of Massachusetts, and H. H. Magdsick, of the National Lamp Works. J. H. Sommers represented George Stickney of the General Electric Co. Others present were A. C. Dick, of the Westinghouse Lamp Works; G. F. Prideaux, of the Edison Lamp Works; W. C. Brown, of the National Lamp Works, and R. S. Burnett and C. E. Heywood, of the Society's Standards Department.

MEMBERS OF THE ILLUMINATING ENGINEERING SOCIETY'S MOTOR VEHICLE LIGHTING COMMITTEE
From Left to Right They Are C. E. Godley, L. C. Porter, A. W. Devine, J. H. Sommers, H. H. Magdsick, A. C. Dick, W. C. Brown, W. F. Little and E. C. Crittenden

At the meeting held prior to the tests, Mr. Devine, who has been retained temporarily by the State of New York to organize its Division of Head-Lamp Inspection, stated that an inspection of the head-lamps on 162 cars recently stopped near Albany gave the following results in percentage:

Satisfactory	7
Without an Approved Device	17
With Twisted Lens	13
With Defective Reflectors	39
Out of Focus	80
Glaring	78
Insufficient Light Sources	20

Figures recently given out by the National Automobile Chamber of Commerce indicate that during the first 9 months of this year, 27 fatalities have resulted because of too strong lights on vehicles and 14 to confusion in dimming.

FLEXIBLE-DISC SERIES ADOPTED

Brake-Lining Tests Discussed at Parts and Fittings Division Meeting

At a meeting of the Parts and Fittings Division members held in Detroit on Oct. 21 a definite series of dimensions for flexible-discs intended for generator, magneto and distributor drives was approved for adoption as S.A.E. Recommended Practice. The series was based on a survey of the practice of engine builders and automobile companies buliding their own engines. The survey showed an astonishing variation in practice. Thirteen sizes of 3-in. flexible-discs were reported, each being different as regards the inside diameter, the bolt-circle diameter, the thickness or the bolt-hole diameter. The complete survey showed that 55 manufacturers used 48 different sizes.

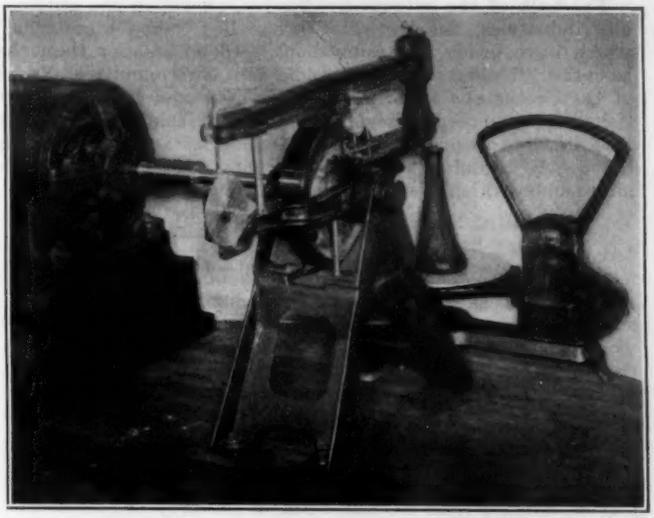
The Division recommendation, which is given in the accompanying table, was based largely on present practice, certain dimensions being changed to make a well-proportioned series suitable for all applications. It is believed that the adoption of this standard in future practice will greatly benefit the disc manufacturers and result in their savings being passed on to the engine and car manufacturers. Servicing of cars using standard sizes would also be greatly facilitated.

FOUR-BOLT TYPE FLEXIBLE-DISC DIMENSIONS

Nominal Size	Outside Diameter ±0.020	Inside Diameter ±0.020	Bolt-Circle Diameter ±0.008	Distance Between Bolt-Holes ±0.010	Bolt-Hole Diameter +0.010 −0.000	Thickness +0.020 −0.010
2¾x¼	2.750	1.000	2.000	1.414	0.250	0.250
3 x¼	3.000	1.250	2.250	1.591	0.250	0.250
3¼x¼	3.250	1.250	2.500	1.768	0.312	0.250
3½x¼	3.500	1.250	2.750	1.944	0.312	0.250
3¾x¼	3.750	1.250	3.000	2.121	0.312	0.250
4 x¼	4.000	1.500	3.125	2.210	0.312	0.250

L. T. Knocke, reporting for Clarence Carson, chairman of the Subdivision on Brake-Lining, said that tests to determine the basis for brake-lining specifications are being continued with the new testing machine developed by Mr. Carson, but that it was still too early to make any definite conclusions. A summary of results covering tests of 17 sets of samples showed, according to Mr. Knocke, an average wear of from 0.00032 to 0.0065 in. per hr., an average coefficient of friction of from 0.340 to 0.850 and a minimum coefficient of friction of from 0.07 to 0.42. These tests were run at a brake-drum speed of 600 r.p.m., or approximately 2200 ft. per min., absorbing 3 hp. at a temperature of about 500 deg. fahr.

The machine used for these tests was developed by Mr. Carson as a result of the tests made by the Subdivision members and the Bureau of Standards on an earlier type of testing machine. It is shown in the accompanying illustration. Although all tests have been made hitherto on dry brake-lining, it was considered desirable and feasible to determine the comparative characteristics of wet brake-lining.



BRAKE-TESTING MACHINE DEVELOPED BY CLARENCE CARSON
The Result of Tests Made by Mr. Carson Will Be Submitted to the Subdivision on Brake-Lining on Which Is Represented both Car and Brake-Lining Makers and the Bureau of Standards

Other subjects considered at the meeting, on which no definite action was taken, were serrated shaft-fittings, shock-absorber mountings and steering-gears. Those present at the meeting were Chairman W. C. Keys, of the Gabriel Snubber Sales & Service Co.; Arthur Boor, of the Willys-Overland Co.; H. S. Jandus, of the C. G. Spring Co.; S. V. Norton, of the General Motors Truck Co.; E. W. Weaver, of the George T. Trundle, Jr. Engineering Co.; F. G. Whittington, of the Stewart-Warner Speedometer Corporation; L. T. Knocke, of Dodge Bros.; A. W. Reader, of the General Motors Corporation; F. F. Chandler, of the Ross Gear & Tool Co., and Standards Manager R. S. Burnett.

INTERNATIONAL CONFERENCE HELD

Possibility of Square and Hexagonal Bolt and Nut Standardization Discussed

An informal conference was held in New York City on Oct. 28 by the American Society of Mechanical Engineers and the Society, sponsors for the Sectional Committee on Bolt, Nut and Rivet Proportions, under the auspices of the American Engineering Standards Committee, so that members of the Sectional Committee could meet representatives of the German and Czecho-Slovakian National Standards Committees who came to this Country for the express purpose of discussing the possibility of international standardization of square and hexagonal-head bolt and nut sizes.

It was brought out at this conference that soon after the war the Germans adopted national standards for bolt and nut diameters and corresponding wrench-openings. This was followed by similar action in Austria, Holland, Sweden and Switzerland, which followed the German work in the principal dimensions, with the result that nuts, wrenches and bolt-heads are interchangeable in all these countries. Czecho-Slovakia, Hungary, Norway, Poland and Russia will probably adopt the same standards the Germans adopted.

In adopting the standards, the Continental countries thought they were closely following American practice. Essentially, what they did was to follow the so-called "United States Standard" dimensions, rounding the wrench openings to the nearest millimeter. It was natural for the Europeans to assume that these dimensions represented actual American practice, since they are widely quoted in handbooks under the misleading title of "United States Standard Bolts and Nuts." Bolts and nuts made to the "standard," however, represent less than 3 per cent of the production in this Country.

The bulk of the present production, except in the automobile industries, follows what are called "shop standards," which have heads and nuts about 1/16 in. smaller than the so-called "United States Standard." Subcommittee No. 2 of the Sectional Committee on Bolt, Nut and Rivet Proportions has proposed a series that is still smaller, by about 1/16 in., and is practically the same series as is specified in the S.A.E. Standard for Screws, Bolts and Nuts. The formulas upon which the three series are based are

United States Standard—$1.5D + 1/8$ in.
Shop Standard—$1.5D + 1/16$ in.
Proposed American Standard—$1.5D$

Results of extensive tests in which actual-service conditions were closely simulated show that the proposed series of nuts are in all cases much stronger than the thread on the bolts. The Germans reported similar results from investigations that they had carried out.

The Europeans stated that in all the Continental countries the opinion is very strong that the same wrench-opening should be used for the nut and the bolt head. In many sizes, the prevailing American practice is to make the head 1/16 in. smaller than the nut. But in the proposed American Standard they will be the same in most sizes.

Those present at the conference were Dr. Edward Schmidt, of the Skoda Works, Prague; Dr. Gustav Schmidt, president of the German Bolt & Nut Manufacturer's Society; Werner T. Schaurte, president of the Bauer & Schaurte and the Rhenish Bolt & Nut Works, Inc.; Alfred Dorn, of the German Standards Committee; Dr. W. F. Durand and C. B. LePage, of the American Society of Mechanical Engineers; Dr. P. G. Agnew, F. J. Schlink and J. Gaillard, of the American Engineering Standards Committee, and Prof. A. E. Norton, chairman of the Sectional Committee on Bolt, Nut and Rivet Proportions. Sectional Committee members present were E. Burdsall, J. H. Edmonds, M. C. Horine, P. G. Lang, Jr., J. H. Vermeulen and W. S. Swain.

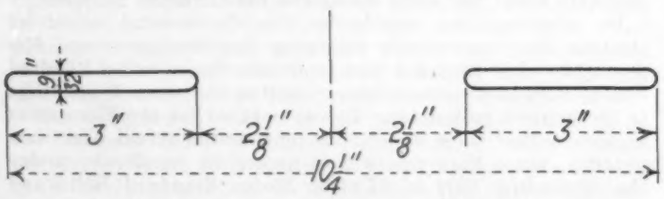
It was unanimously agreed by all present that world-wide uniformity in wrench openings is so important that it would be desirable to discuss the matter in the near future at a general international conference. It was agreed that each of the groups of representatives of each country present would take up the matter of such a conference with its own national standardizing body.

LICENSE-PLATE BRACKET-SLOTS ADOPTED

Proposed Dimensions Permit Mounting Plates Used by Every State in Union

An irritating difficulty that every car manufacturer experiences is selecting dimensions for license-plate bracket-slots which will permit future owners to mount the plates furnished by the State authorities without recourse to drilling or punching holes. This condition has, of course, been caused by the utter lack of standardization in State license-plates.

Recognizing that the only reason for this lack of uniformity is that the punching of license-plates was left to the individual judgment of the officials in charge of licensing motor vehicles, or to the plate manufacturers, the Parts and Fittings Division, through the Standards Department, undertook to obtain license-plate uniformity. It was found impossible, however, to obtain any cooperative action from the States because of lack of authority, divided authority or lack of interest. This was experienced principally with the States having a relatively small motor-vehicle registration, real interest being shown by those States having large registrations and well-organized motor-vehicle bureaus.



PROPOSED DIMENSIONS FOR LICENSE-PLATE BRACKET-SLOTS
Brackets with Slots as Shown Will Enable License Plates for 46 of the 48 States To Be Mounted without Any Difficulty

The Division then considered the problem entirely from the viewpoint of the automobile manufacturer. License-plate bracket-slot dimensions were determined upon which it was thought would permit mounting any license-plate punched in the usual manner. The slot dimensions proposed, which are given in the accompanying illustration, are practically in agreement with the rear license-plate bracket-slot dimensions required by the State of Massachusetts and the Society has recently been informed that the Massachusetts regulations will be revised in the near future to specify the exact dimensions proposed by the Division.

To determine definitely which, if any, States are punching license-plates in a way that would not permit their being mounted on brackets slotted as proposed by the Division, each State was asked to submit definite information as to the license-plate punching being used by it. Information was submitted by 46 States, only Louisiana and Mississippi not replying.

A checking of the information showed that the plates of the States replying can be mounted on brackets punched as proposed without any difficulty, provided holding screws larger than ¼ in. are not used. All of these State plates would be centered on the bracket with the exception of the Florida plate which would be 1 in. off center.

As soon as the recommendation is officially approved by the Society, copies of the standard will be transmitted to every State Secretary so that greater uniformity of license-plate punching may obtain in the future.

ENGINE DIVISION MEETS IN DETROIT

Support Arms and Trunnions, Flywheel Housings and Starting-Cranks Considered

On Oct. 9 the Engine Division held a meeting at Detroit in the rooms of the Old Colony Club. Several recommendations covering engine parts were approved and further work was undertaken. Those present were R. J. Broege, of the Buda Co., chairman; S. F. Evelyn; G. Walker Gilmer, Jr., of the L. H. Gilmer Co.; L. P. Kalb, of the Continental Motors Corporation; M. J. Steele, of the Packard Motor Car Co.; R. C. Darnell, of the Northway Motor & Mfg. Co., and Standards Manager R. S. Burnett.

The present S.A.E. Standard for Engine Support-Arms does not specify the width or the depth of the arms. In view of the fact that a survey of present practice showed that practice has crystallized to a considerable extent, the members were able to select definite dimensions for the width of the bottom face of the arms. The dimensions recommended are: 4 in. for the No. 1 housing, 3½ in. for the Nos. 2 and 3 housings and 2¾ in. for the Nos. 4 and 5 housings. The widths recommended permit the use of anti-squeak pads. Definite heights were not recommended. The height governs only the bolt length. Moreover the specification of it might limit design.

The advisability of recommending dimensions for plain transmission-shaft pilot-bearings was considered. It was believed that the plain type of bearing should not be used, but that where the ball bearing cannot be used, an oilless bearing that will be interchangeable with the No. 205 standard ball-bearing should be used. Further information is to be obtained from engine builders before final action is taken.

A new size of flywheel housing was also approved at this meeting. This action was taken because information had been submitted to the Division indicating that for industrial applications a larger size of flywheel than the S.A.E. Standard No. 1 size is necessary. The dimensions approved for this size of housing, which is to be known as the No. 0 size, are 25.50 to 25.51 in. for the inside diameter of the

flywheel housing flange, 28½ in. for the outside diameter of the flywheel housing, 26¾ in. for the bolt-circle diameter and 28 in. for the outside diameter of the flange face. Sixteen holes, tapped for ½-13 NC threads, equally spaced on the vertical center-line are to be used.

Standardization of engine trunnions was considered, this subject having been proposed by a motor-truck manufacturer. A Subdivision consisting of A. A. Bull, chairman, L. P. Kalb and M. J. Steele was appointed to obtain information on present practice and draw up a preliminary recommendation.

The work on standardization of starting-cranks was reviewed by S. F. Evelyn, who submitted a preliminary report covering three sizes each of three and four-jaw types. It was not considered desirable to standardize the distance from the jaws to the crank handle or to standardize the design of the handle, because of the unavoidable large variety of lengths that would be required and to meet various ideas as to design. It was agreed that a standard for the jaw members only would be a valuable accomplishment and be much more apt to be adopted by all manufacturers than a complete design would be.

Mr. Kalb was delegated to carry on further work on this subject.

SCREW-THREAD FITS RECOMMENDED

Action Taken at Last Division Meeting, Including Castle-Nut Slot Gaging

At the meeting of the Screw-Threads Division held in Detroit on Oct. 24, definite fits were selected for the screw-threads specified in existing S.A.E. Standards, for which fits and tolerances have never been adopted. The fits recommended by the Division are as specified in the S.A.E. Standard for Screw-Threads, pp. C1 to C1m of the S.A.E. HANDBOOK. This standard was largely abstracted by the Screw-Threads Division from the report of the Sectional Committee on Screw-Threads, which was organized by the American Society of Mechanical Engineers and the Society. The report was prepared in collaboration with the National Screw Thread Commission on which the two societies were represented. The complete American Standard for Screw-Threads is available in pamphlet form, having been printed by the American Society of Mechanical Engineers.

In the following list of fits recommended by the Screw-Threads Division, the identification symbols used are as specified in the American Standard. The basis of the system is the initial letters of the thread series, followed by the number of the class of fit. Thus, a threaded part of 1 in. diameter, with 14 threads per inch and with the Free (or Class 2) Fit, would be indicated as—1 in.-14-NF-2. The letter "N," standing for "National," is used instead of "A" in order to tie-in with the report of the National Screw Thread Commission.

Page	*Standard*	*Class*
A1	Flywheels and Flywheel Housings	NC-2
A1a	Clutch Housings	NC-2
A1b	Cone-Clutch-Type Flywheels	NC-3
A1b	Tractor Flywheel-Housings	NC-2
A5	Connecting-Rod Bolts	NF-3
A8	Carbureter Flanges	NC-2
A14b, A14c	Fan-Pulley Spindles	NF-2
A26	Radiator Flanges	NC-2
A27	Radiator-Header Bolts	NC-2
B1	Head-Lamps	NF-2
B2	Tail-Lamp Mountings	NC-2
B14	Magneto Mountings	NC-2
B15	Generator Flange-Type Mounting	NF-2
B15a	Generator Bracket-Type Mounting	
	Shaft-End	NF-2
	Base Screws	NC-2
B16b	Starting-Motor Mounting	NC-2
C2	Screws, Bolts and Nuts	NF-2
C4a	High Nuts	N(C or F)-2
C8	Rod-Ends	NF-2
C45a	Pressure Gages	NF-2
C52	Ball-and-Socket Joints	NF-2
C58b	Ball-Studs	NF-2
E1	Tire-Pump Mounting	NC-2
H3	Spring Rebound-Clip Bolts	NC-2
H4	Spring Center-Bolts	NF-2
J2	Control-Lever Ball-Handle Inserts	NF-2
J3	Carbureter Throttle Levers	NF-2
L1	Door Locks and Handles	NF-2
L4	Top-Irons	NC-2

The Division also approved the proposed method of gaging castle-nut slots which was submitted by E. H. Ehrman and printed in full on p. 185 of the September issue of THE JOURNAL. This recommendation will be included as a supplement to the present S.A.E. Standard for Screws, Bolts and Nuts. The tap-drill reference tables, which were printed in full in the June issue, p. 578, were also discussed. It was decided to limit these tables to the drill sizes up to and including 1 in. only, because larger holes are usually reamed before tapping and the information contained in the tables would not therefore apply; and to limit the tables to "Drill Sizes for General Use" and "Reference Tables for Tapped-Hole Diameters—Basic, Maximum or Minimum—and Nearest Drill-Sizes." E. H. Ehrman reported results of an extensive analysis of tire-valve threads, including caps, dust-caps, felloe nuts, tube nuts and stems. Tolerances will be worked out for these threads, with the cooperation of the Tire & Rim Association of America.

Classification of thread fits for the following special threads was referred to Earle Buckingham, as special fits are necessary for each: Breaker-Contacts, Square and Taper Fittings, Fuel and Lubrication Tube-Fittings, Oil and Grease-Cup Threads, Tank and Radiator Caps, Three-Joint Propeller-Shafts, Hub Odometers, Motorcycle Spokes and Steering-Wheel Hubs.

The Division members present at the meeting, which was held in the rooms of the Old Colony Club, were E. H. Ehrman, of the Standard Screw Co., chairman; A. Boor, of the Willys-Overland Co.; Earle Buckingham, of the Pratt & Whitney Co.; G. S. Case, of the Lamson & Sessions Co.; H. H. Edge, of the Hanson Tap & Gauge Co.; F. R. Lamb, of the Studebaker Corporation of America; A. W. Reader, of the General Motors Corporation, and Standards Manager R. S. Burnett.

BOOK OF STANDARDS ISSUED

American Society for Testing Materials 1924 Volume Contains 220 Standards

The 1924 Book of Standards of the American Society for Testing Materials has recently been issued. This book of standards, which is revised every 3 years, contains 1230 pages and 220 separate standards.

Many S.A.E. Standards specify tests made in accordance with the requirements of the American Society for Testing Materials. This is in accord with the recognized policy of the Standards Committee to refer the development of specifications relating to detailed tests to the American Society for Testing Materials in order that there may be no unnecessary duplication of work.

AUTOMOTIVE RESEARCH

The Society's activities as well as research matters of general interest are presented in this section

ANTI-FREEZING SOLUTIONS

A Timely Topic Is Discussed and Some Interesting Data Are Presented

Because of the constantly recurring interest in anti-freezing compounds at this season of the year, it is believed desirable at this time to present again in these columns data that have been revised and somewhat amplified since they were first published in the November, 1921, issue of THE JOURNAL. The material contained in this article is based upon work reported by the Bureau of Standards, where the subject has been investigated very thoroughly.

The freezing-points of various solutions have been determined and the corrosive effects of such solutions upon the metals commonly employed in automobile radiator construction have been investigated. Inasmuch as electrolytic action is largely responsible for radiator corrosion, corrosive effects were studied upon the combinations of metals ordinarily used in radiators.

IDEAL REQUIREMENTS OF AN ANTI-FREEZING COMPOUND

The ideal anti-freezing compound is one that will prevent freezing of the radiator liquid without injuring either the engine or the radiator, that will not lose its non-freezing properties after continued use and that does not materially change the boiling-point of water when dissolved in it. There are two general types of anti-freezing compounds: one a solution in water of alcohol or glycerine or a mixture of the latter two, the other a solution in water of calcium chloride. Kerosene and similar oils, without admixture, are sometimes used, as well as solutions of glucose or honey in water. Glucose and honey, however, are not sufficiently effective as anti-freezing agents to merit detailed consideration here. Low-percentage honey mixtures do not have a sufficiently low freezing-point, and high-percentage mixtures are so viscous that they circulate very slowly or not at all. Glucose solutions are even less effective than honey.

OBJECTIONS TO THE USE OF KEROSENE

Kerosene should never be used in a cooling system in which the liquid is not circulated by a pump. Its use in any system is undesirable as the inflammability of its vapor makes it dangerous, and its high and uncertain boiling point may lead to the serious over-heating of the engine or even to the melting of the solder in the radiator. It also has a slight solvent action on rubber.

CHARACTERISTICS OF CALCIUM-CHLORIDE PREPARATIONS

Calcium-chloride preparations are sold under a variety of names. Their ability to prevent freezing if properly prepared is unquestioned. Solutions of calcium chloride and water are known to have a corrosive action on the engine jacket, on the solder in the radiator and on aluminum which is sometimes used in manifolds, pumps and headers. The effect on solder and aluminum is especially serious. Certain calcium-chloride preparations contain a small amount of a soluble chromate added for the purpose of retarding this corrosive action. Laboratory tests indicate that such preparations have practically no corrosive action on the metals used in the construction of automobile radiators with the exception of aluminum.

Another troublesome effect of all calcium-chloride solutions is experienced if the solution comes in contact with spark-plugs or ignition wires. The salt deposited when the water evaporates is very difficult to remove and, when it cools, it absorbs water and becomes a good electrical conductor, thus causing short-circuits that are not easy to locate, inasmuch as they disappear when the engine is heated up.

PREPARING NON-FREEZING SOLUTIONS OF ALCOHOL AND GLYCERINE

The alcohol solutions are, in general, considered the most satisfactory. They do not have any appreciable corrosive action. This can be predicted from theoretical considerations and is well established in practice. Wood alcohol, however, sometimes contains free acid which is objectionable; for this reason it should not be used unless it is known to be free from such acids.

The chief objection to alcohol is that it continually boils out of the solution and must be replaced at short intervals if the proper proportion of alcohol is to be maintained. Glycerine is frequently substituted for part of the alcohol for the purpose of reducing evaporation. The most practical method of maintaining the proper quantity of alcohol in the solution is, first, to determine the specific gravity of the liquid by a hydrometer and then, by reference to Table 1, to add the necessary quantity of alcohol to obtain the desired specific gravity. Care should be taken to have the solution thoroughly mixed; and, as the specific gravities given in the table are obtained at 60 deg. fahr., the specific gravity should be measured when the temperature of the solution is between 55 and 65 deg. fahr. The solution may then be kept at the proper strength from day to day by the addition of alcohol until the hydrometer reads the same as when first noted.

To illustrate how a non-freezing solution is prepared by the use of Table 1, assume that the lowest temperature anticipated is 19 deg. fahr. and that denatured alcohol is to be used. By reference to the table in the column marked Denatured Alcohol, + 19 deg. fahr. is found in the 20-Per Cent Solution group, and the specific gravity of that solution is 0.978. If the radiator holds 3.5 gal., 20 per cent of this must be alcohol and the remaining 80 per cent water; 20 per cent of 3.5 gal. is 0.7 gal. or a little more than 5.5 pints. This amount should be added to enough water to make 3.5 gal., that is, the water used will be 2.8 gal., a little more than 11 quarts. If the temperature of this solution is brought to 60 deg. fahr. and an accurate hydrometer is floated in it, the hydrometer should read 0.978. If the reading is higher than 0.978, more alcohol should be added with constant stirring until the 0.978 mark is reached. An accurate hydrometer should read 1.000 when placed in water at 60 deg. fahr., and 0.834 in 180-deg. proof alcohol at the same temperature. The denatured alcohol usually sold by dealers is 180 deg. proof, which is the minimum allowed by law. A solution so prepared will not begin to freeze until its temperature is approximately + 19 deg. fahr.

Table 1 gives freezing-points obtained from actual measurements made at the Bureau of Standards on solutions of commercial materials, which may be considered sufficiently accurate for practical purposes, since they agree fairly well with the most reliable scientific data. The freezing-point is taken to be that temperature in the cooling process at which crystals begin to form. The temperature at which the entire mass becomes solid may be several degrees lower than the freezing-point of dilute solutions, and 10 to 15 deg. lower

TABLE 1—FREEZING-POINTS AND SPECIFIC GRAVITIES OF THE BUREAU OF STANDARDS ALCOHOL AND GLYCERINE ANTI-FREEZING SOLUTIONS

	Denatured Alcohol	Wood Alcohol	Glycerine[1]	Denatured Alcohol and Glycerine[2]	Wood Alcohol and Glycerine[2]
10-Per Cent Solution[3]					
Freezing-Point, deg. cent.	— 3	— 5	— 2	— 4	— 4
deg. fahr.	+27	+23	+29	+25	+25
Specific Gravity at 60 deg. fahr.	0.988	0.987	——	——	——
20-Per Cent Solution					
Freezing-Point, deg. cent.	— 7	—12	— 6	— 8	— 9
deg. fahr.	+19	+10	+21	+18	+16
Specific Gravity at 60 deg. fahr.	0.978	0.975	——	——	——
30-Per Cent Solution					
Freezing-Point, deg. cent.	—12	—19	—11	—13	—15
deg. fahr.	+10	— 2	+12	+ 9	+ 5
Specific Gravity at 60 deg. fahr.	0.968	0.963	——	——	——
40-Per Cent Solution					
Freezing-Point, deg. cent.	—19	—29	—18	—22	—24
deg. fahr.	— 2	—20	0	— 8	—11
Specific Gravity at 60 deg. fahr.	0.957	0.952	——	——	——
50-Per Cent Solution					
Freezing-Point, deg. cent.	—28	—40	—26	—32	—35
deg. fahr.	—18	—40	—15	—26	—31
Specific Gravity at 60 deg. fahr.	0.943	0.937	——	——	——

[1] The specific gravity, at 60 deg. fahr., of the concentrated glycerol used in making up these solutions was 1.2537.

[2] Glycerine and alcohol are mixed in equal proportions: a 10-per cent solution of glycerine and alcohol, for instance, means that 5 parts of glycerine and 5 parts of alcohol should be added to 90 parts of water.

[3] Percentage, by volume, in water.

for the more concentrated solutions. As an example, a 30-per cent solution of denatured alcohol begins to freeze, that is, small crystals of ice form, at 7 deg. fahr., but the solution does not freeze solid until a temperature of — 5 deg. fahr. or lower is reached. Hence, a temperature considerably lower than that given in the table for any given percentage of alcohol would not injure the engine or the radiator. However, it seems desirable to keep the solution at such a concentration that ice crystals will not form at the lowest temperature to be encountered, since such crystals may interfere with circulation.

Method of Reading a Hydrometer

When hydrometer readings are to be taken, the solution is placed in a clear glass cylinder and the hydrometer, after being carefully immersed in it, to a point slightly below that to which it naturally sinks, is then allowed to float freely. In taking the reading the eye should be placed slightly below the plane of the surface of the liquid and then raised slowly until this surface, seen as an ellipse, becomes a straight line. The point at which this line cuts the hydrometer scale should be taken as the reading of the instrument.

CARBON REMOVED BY LOADING

Full-Throttle Operation Eliminates Heavy Deposits in 2 Hr.

Statements appear from time to time regarding the influence of a given fuel or oil upon the deposition of carbon in automotive engines. Recent tests at the Bureau of Standards demonstrate that rather exhaustive tests are necessary for distinguishing between the results due to the use of a certain fuel or oil and those due to changes in conditions of operation.

The latter effects are indicated very clearly by the accompanying illustrations. Fig. 1 shows a cylinder-head after a period of operation at moderate load, the operator having been somewhat over-generous in the matter of fuel and oil. The cylinder-head, still in the condition shown in Fig. 1, was put back in place and the engine was operated at nearly full-throttle for less than 2 hr. with a somewhat leaner mixture. Fig. 2 shows the effect of this running upon the carbon posits. It will be noted that the deposits upon the valves and around the spark-plugs have been removed.

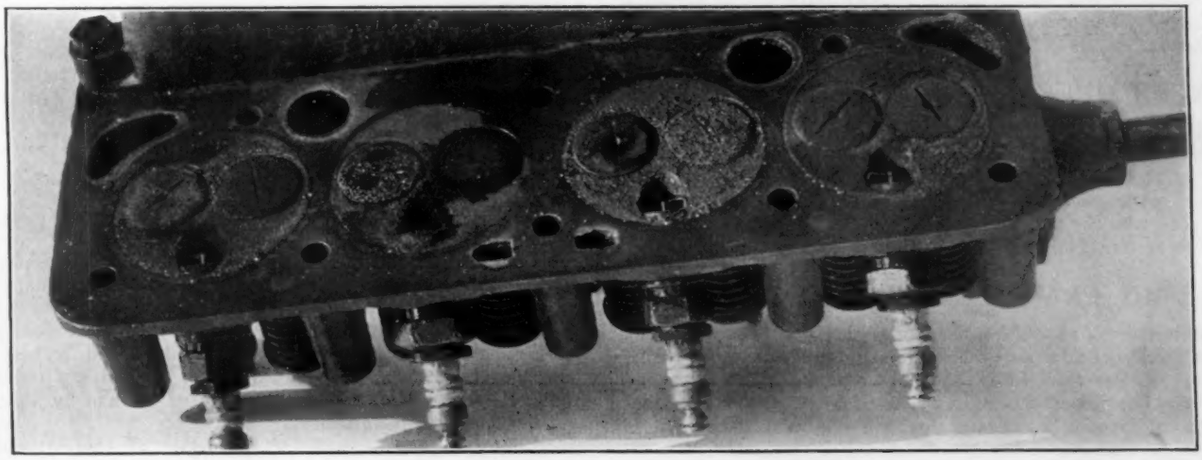


Fig. 1—Cylinder-Head with Carbon Deposits
These Deposits, Which Can Be Plainly Seen, Accumulated during a Run with Excessive Oil and a Rich Fuel-Mixture

FIG. 2—THE SAME CYLINDER-HEADS AFTER ANOTHER RUN
This View Shows the Carbon Deposits Illustrated in Fig. 1 Completely Removed as a Result of Running for Less than 2 Hr. at Nearly Full Throttle and with a Leaner Mixture

This article should not be construed as advocating this method of carbon removal. In fact, it is even possible that operating a badly carbonized engine at full throttle might, in certain cases, cause detonation or preignition of such severity as to result in actual damage to the bearings, the valves and other parts. The real purpose in presenting these results is to show to what extent the presence of carbon is influenced by conditions of engine operation.

MEETINGS OF THE SOCIETY

(*Concluded from p.* 490)

POINTS BROUGHT OUT IN THE DISCUSSION

Chairman Herrington called upon W. E. Kemp to discuss Mr. Dollinger's paper. Mr. Kemp thoroughly agreed with the important points raised and called attention to the requirement that suitable air-cleaners should not clog and cause an excessive depression at the carbureter inlet. He believed that the designer should assume certain requirements for engine efficiency and that the air-cleaner should be built in such a way as not to interfere with this criterion of performance.

A member stated that air-cleaners should be given more careful attention by the owner. He emphasized the fact that air-cleaners are very necessary on trucks where the engine works at capacity during a large percentage of the time.

Various methods of cleaning the filter types of air-cleaner were discussed. One interesting method consisted in mounting the filter insert horizontally on a rotating hollow-spindle and introducing gasoline through the spindle in such a way that it enters the insert and is thrown outward by centrifugal force so as to carry the dirt particles with it as it leaves the insert.

WINTER OPERATION MINNEAPOLIS TOPIC

Activities of the Minneapolis Section were resumed with a meeting on Nov. 20 devoted to the timely topic Winter Operation of Motor Cars. Effects of fuel and carburetion on cold weather operations were described by O. C. Berry. C. F. Kelleher gave the members an insight into the chemistry of anti-freeze materials for use in the cooling system of cars.

SAN FRANCISCO GROUP MEETS

Possibilities of extending the use of the internal-combustion engine by hydraulic power transmission were described at a meeting of the San Francisco members of the Society on Nov. 20. The paper was read by A. C. Luetgert, an engineer who has developed successful logging engines of the Diesel type.

The next meeting of the members residing in and near San Francisco will be held at the Hotel Whitcomb on Dec. 18 at 6.30 p. m. Noyes J. Murphy of the C. L. Best Tractor Co. will give a talk on modern development of the medium-speed Diesel engine using solid injection. The talk will be illustrated with lantern slides. W. W. MacDonald is chairman of the committee that is arranging these meetings in San Francisco. A. A. MacCallum, the secretary, may be addressed at 115 New Montgomery Street, San Francisco.

PROPOSED LOS ANGELES GROUP MEETING

Members of the Society residing on the Pacific Coast will be interested in a further extension of the Society's activities in the Far West. Ethelbert Favary, formerly active in the affairs of the Metropolitan Section, has found a demand in Los Angeles for technical meetings on automotive subjects. As a result, Mr. Favary has been entrusted with the inauguration of informal meetings to which all Society members and their friends are invited.

A meeting has been arranged tentatively for the evening of Jan. 9. The topic will be Six-Wheel Trucks. Differences between various types of construction used for six-wheel trucks will be described. Their effect on the road will be discussed and a mathematical analysis will be made of the road impacts of six-wheel trucks in comparison with four-wheel vehicles. Further details of the meeting will be announced in the January issue of THE JOURNAL or may be secured by writing to Ethelbert Favary, care of Moreland Motor Truck Co., Los Angeles.

MILWAUKEE STUDIES MOTORCYCLES

Milwaukee Section members have a much better conception of motorcycle manufacturing methods since their inspection trip through the plant of the Harley-Davidson Motor Co. on Nov. 5. Some 50 members of the Section were conducted through every department and well-informed guides explained all operations in detail. W. S. Harley acted as genial host and was accorded a vote of thanks by the men who enjoyed his hospitality.

Automotive service will be the topic of the Milwaukee Section meeting on Dec. 3. Charles D. Prinz and E. L. Consoliver will be the speakers of the evening.

Cause and Effects of Shimmying

THE meeting of the Buffalo Section on Oct. 14, took the form of a symposium on the shimmying effects that accompany the use of balloon tires and four-wheel brakes. The subject was introduced by papers presented by J. E. Hale on Adapting Motor Cars to Low Pressure Tires and by R. B. Day on the Correction of Balloon-Tire Shimmying, and was amplified in an extended discussion by E. J. W. Ragsdale. Other speakers contributed comments on concomitant aspects of the phenomenon.

ADAPTING MOTOR CARS TO LOW-PRESSURE TIRES

BY J. E. HALE[1]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

ABSTRACT

BALLOON tires have caused the points at which the greatest trouble formerly occurred to be reversed; the greatest wear hitherto has occurred on the rear tires; now it occurs on the front. The carcasses of old tires were heavy and thick and carried a large part of the load; balloon tires are flexible and will support very little load. The air-pressure carries the load and gives greater cushioning effect. Four-ply tires have proved to be the most satisfactory and have none of the disadvantages of high-pressure tires. Balloon tires steer harder than high-pressure tires because of lower air pressure, which necessitates a greater area of contact. Steering resistance is caused by the load on the tire and the increased area of contact. Many designers, in making the steering gear free to overcome steering resistance, make wheel-twitching possible.

Shimmying may be classified as low-speed and high-speed, the latter occurring at speeds between 35 and 40 m.p.h. and being very violent. By a chronograph, the movement of the cycles of shimmying for different air-pressures was studied. These were found to increase with the air-pressure and with the speed of the car. The shimmying under given pressure and load conditions appears to repeat at the same speed, and to be confined strictly to cars having front-wheel brakes. The axle and wheel mass, greatly increased by the addition of front-wheel brakes, floats between two springs, and in that position is thrown into violent agitation. The forces that produce this agitation are believed to originate in the geometry of the steering-gear, the angle of inclination of the king-pin and the change in the velocity of the wheels. Investigation has shown that the path of the ball connection of the steering-arm is not a truly neutral path so far as steering is concerned and that any action between the frame and the springs will cause the wheels to steer alternately to the right and to the left. The author believes that shimmying can be overcome by correcting this error in the steering linkage. With a view to introducing a flexible steering-connection, a hydraulic gear was tried. This served to eliminate front-wheel shimmying and the twitching of the steering-wheel. Because the axle is not in its lowest position when steering straight ahead, on account of the inclination of the king-pin combined with the caster angle and the wheel camber, the wheels tend to turn in other directions. With the axle-mass throbbing up and down the tendency is to throw the wheels around so that the axle can assume its lowest position. Shimmying, consequently, is produced. Making the king-pin vertical would obviate this tendency. Tables showing the results of tests are appended.

FORMERLY, the rear of the car was the feature that gave tire manufacturers greatest concern. The tires on the front wheels wore better and gave no trouble at all, but the rear tires, being always short-lived, were the ones that caused worry. Strange to say, with balloon tires, the conditions are entirely reversed. The balloon tires on the rear wheels do not give trouble. We do not think of them. They give exceptional mileage and apparently have no drawbacks, since all the clearance problems have been solved and the present problems are all confined to the front end.

The problem of tire standards may seem commonplace, but it is a thing that is being handled in many ways, and is one of the most important aspects of balloon tires. Balloon tires are of many sizes, a fact that makes the problem extremely perplexing.

In Table 1, I have summarized as completely as possible the balloon tire and rim equipment that is being used on all the various makes of cars. The table contains considerable information. A perusal of it will show all sorts of combinations of rim widths for different tire-sections. Although the four-ply tires predominate, some six-ply tires are required.

The carcasses of old tires were heavy and thick and, as a matter of fact, carried a large part of the load. By taking a tire not on the rim and standing on the lower portion when it is in an upright position, it will be noticed that the tire can hardly be flattened out. If a like treatment is accorded to a balloon tire, you will notice its greater flexing qualities. You can see that the balloon tire itself has very little carrying-capacity; in other words, the carcass will support very little load. The air is carrying the load and that, of course, is its purpose if we are to get the full benefit of the air as a cushioning medium.

Advantage of Four-Ply Tires

To take advantage of the lower pressure, we must have a tire that can flex to the maximum degree, yet not have tire trouble in any form. Two plies might be suggested. It happens that two-ply tires are too frail, but we find that four-ply tires are very satisfactory, as is indicated by the puncture data presented in Table 2. If we go through the major forms of tire trouble that we recognize, we find that we have no bead trouble, no separation; in other words, four-ply tires have none of the disadvantages of the high-pressure tires.

[1] M.S.A.E.—Manager of the development department, Firestone Tire & Rubber Co., Akron, Ohio.

In six-ply tires the casing must be smaller and, if the section is smaller, the pressure must be higher, because the limitation in flexing necessitates a limitation in the vertical deflection. Low pressure calls for a larger area of contact and, if we have low air-pressure, the section must be larger to allow for it without excessive deflection.

It is unfair to say that balloon tires steer harder than do high-pressure tires without taking into consideration the fact that high-pressure tires would also steer hard if they were operated at balloon-tire pressure. In other words, the public intends to ride on low air-pressure; and the moment they begin to ride on low air-pressure, they will have more steering resistance. Consequently, if steering resistance is objectionable, this must be considered in the design of the car.

Steering resistance is caused by two things: (*a*) the load on the tire and (*b*) the area of contact. I say nothing at all about the size of the tire, for the size has nothing to do with it. The area of contact is controlled by the air-pressure; if the pressure is low, the area will be larger because, with the lower air-pressure, the tire automatically flattens out. I am of the opinion that steering resistance is caused largely by the design of the steering-gear itself.

We investigated the steering-resistance problem by measuring the force necessary to actuate the drag-link on two different cars, for we believed that if we measured this force under comparative circumstances, we should get a clear picture of what the actual resistance is. The results of this investigation are shown in Table 3.

Another problem, in my judgment, will become as serious as shimmying. I believe that all the car designers are making the steering-gear free, to overcome the steering resistance. In doing so, in the majority of cases, they are making wheel-twitching possible. In cars that have the freest steering, wheel-twitching is already quite noticeable. In my judgment, the problem will be serious. I predict that it will be one that we shall hear a great deal about, and that it will be of much concern to the car-designer before it is solved.

TABLE 2—PUNCTURE DATA ON BALLOON TIRES

Tire Section	Number of Tires	Car-Miles	Number of Punctures	Average Miles per Puncture
4.40	118	251,832	54	4,663
5.25	35	100,771	11	9,161
6.20	31	68,906	5	13,781
7.30	115	246,044	32	7,688

Number of Flats per Tire per Month in Taxi Service

High-Pressure		Balloon	
30 x 5	33 x 4½	6.20	7.30
0.92	1.79	0.67	0.84

Drop-Center Rims

What do we think of drop-center rims? We are in the tire business. We are anxious that rims that are a proper and safe mounting for the tires shall be used on all motor cars, and that they shall be perfected so that no tube troubles will develop. If drop-center rims meet these conditions, no objection to them will be made, as the question of drop-center rims is a matter of cost, weight and ease of changing tires.

I am not and I do not believe that any tiremaker is opposed to drop-center rims. It is my belief that many thousand drop-center rims must be run in the hands of the public before we shall know the answer, for I do not believe that anyone can positively tell the whole story at this time. The idea, however, is attractive enough so that it should be thoroughly tested.

Getting back to the shimmy question; in the first place, I suspect that not more than 2 per cent of those present have ever experienced really good shimmying. They say, "Yes, my car shimmies" but, I find that when they have been cross-examined a little, they have been in a car that was only a little shaky in the front end. The kind of shimmying I am talking about is of extreme violence.

We recognize a low-speed and a high-speed shimmying. High-speed shimmying occurs when the car is going from 35 to 40 m.p.h. and over, and is very violent. If

TABLE 1—CURRENT REQUIREMENTS OF BALLOON TIRES AND RIMS FOR ORIGINAL EQUIPMENT

Tire Section	Rim Diameter, In.	Number of Plies	Rim Section In.	Car Manufacturers Using
4.40	21	4	3.5	Ford, Gray
4.95	20	4	4.0	Star
4.95	22	4	4.0	Buick, Oakland, Oldsmobile
5.25	20	4	4.0	Durant, Flint, Gardner, Maxwell, Moon
5.25	21	4	4.0	Anderson, Auburn, Cleveland, Columbia, Essex, Elcar, Franklin, Gardner, Hupp, Jewett, Lexington, Moon, Rollin, Willys-Overland
5.25	21	4	4.5	Nash, Studebaker
5.77	20	4 & 5	4.0	Dodge
5.77	20	6	4.0	Chrysler
5.77	22	4	4.5	Buick, Rickenbacker
5.77	22	6	4.5	Buick, Pierce-Arrow
6.00	21	4	4.0	Velie
6.00	21	4	4.5	Chandler
6.00	21	4	5.0	Nash, Stearns
6.00	21	4	4.5	Chandler
6.20	20	4	4.0	Anderson, Elcar, Moon, Reo, Westcott
6.20	20	4	4.5	Apperson, Auburn, Case, Flint, H. C. S., Jordan, Kissel, Lexington, McFarlan, Meteor, Marmon, Premier, Saywers-Scovill, Stutz, Wills-St. Claire, Willys-Overland
6.20	20	4	5.0	Studebaker
6.20	21	4	4.0	Apperson
6.20	21	4	4.5	Hudson, Packard, Peerless
6.75	21	4	4.5	Paige, Stearns
6.75	21	6	5.0	Lincoln, Peerless
6.75	21	6	6.0	Cadillac
7.30	20	4	4.5	Case, Cole, McFarlan, Meteor, Marmon, Pierce-Arrow, Sayers-Scovill
7.30	20	4	5.0	Cunningham, Packard, Studebaker

TABLE 3—DYNAMOMETER TESTS OF STEERING RESISTANCE

Load, per front wheel, lb.		1200						475	
Tire Size		7.30/20		33 x 5-in.		4.40/21		30 x 3½-in.	
Kind of Tire		Balloon		High-Pressure		Balloon		Fabric	
Inflation-Pressure, lb. per sq. in.		25	50	25	50	25	50	25	50
Road Contact	Area, sq. in.	41.28	25.85	34.58	24.40	12.40	7.69	10.42	7.42
	Length, in.	11.30	9.32	10.85	8.95	7.55	6.08	7.60	6.30
	Width, in.	4.50	3.30	3.63	3.30	1.93	1.58	1.70	1.55
Tension in Drag-Link	Dry Concrete, lb.	930	715	900	700	325	250	275	250
	Muddy Concrete, lb.	800	565	775	550	225	175	200	175
	Cinder, lb.	950	790	925	775	400	275	285	250

you are riding in a car that shimmies violently at 50 m.p.h., the experience is terrifying.

Causes of High-Speed Shimmying

I consider it important to record as truthfully as possible my conception of what constitutes high-speed shimmying. I have ridden in several different makes of car with the front fenders off in attempting to analyze what is taking place. What one observes is that the frame and the body of the car are moving up and down with respect to the axle, and that one side is up when the other is down. Because of this, one of the most noticeable aspects of shimmying is the swaying of the radiator and of the hood from side to side. At the same time that this is happening and in absolute synchronism with it, the front wheels are steering alternately to the right and to the left. In some cars, the alternation of the front wheels in steering from side to side is so violent that it reacts on the steering-gear, particularly if the steering-gear is the least bit reversible. In some cases, the action is so violent that it is impossible to hold the steering-wheel quiet.

We found that even when the fenders were off, the movements of the front end of the car were so extremely rapid that the eye could not follow them, so, deciding to investigate in another way, we bolted a chronograph to the front end of the frame, as is shown in Fig. 1. This instrument is simply a roll of paper that is driven by clockwork and arranged so that a pencil connected by linkage with the axle can record on the paper the vertical movement of the frame with respect to the axle. The instrument was electrically controlled from the rear seat, since it was too dangerous for a man to ride in the front of the car.

A sample of the graph, shown in Fig. 2, was taken

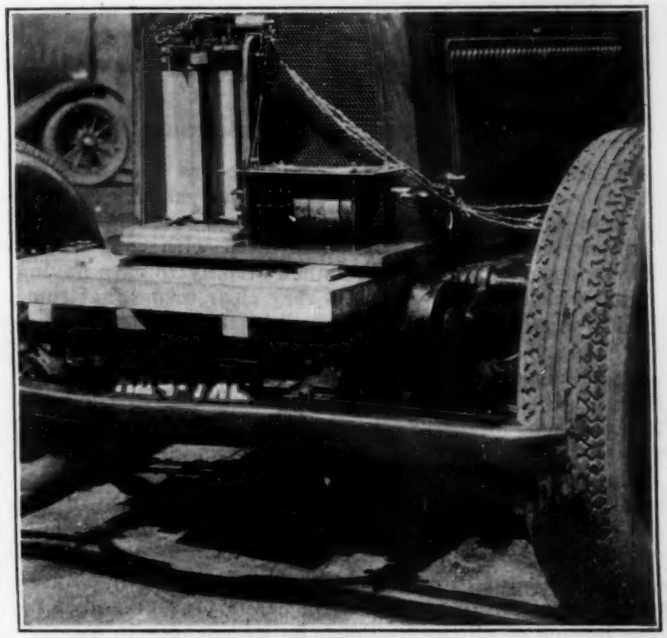


Fig. 1—Chronograph Used To Record the Vertical Movement of the Frame with Respect to the Axle

This Instrument Was Simply a Roll of Paper Driven by Clockwork and Arranged So That a Pencil Could Be Connected by Linkage to the Axle and Record on the Paper the Movement of the Frame Which Was Too Rapid for the Eye To Follow. Since a Man Could Not Ride in the Front of the Car because of the Danger Involved, the Instrument Was Controlled Electrically from the Rear Seat

TABLE 4—MOVEMENT OF CYCLES OF SHIMMYING FOR DIFFERENT INFLATION-PRESSURES

Inflation-Pressure, lb. per sq. in.	15	25	35
Cycles per Sec.	36	44	50
Speed, m.p.h.	30 to 50	45 to 50	60

when the car was driven over a smooth piece of road containing no holes or imperfect places. It will be noticed that some motion between the spring and the frame occurred at all speeds but that shimmying occurred at the speeds at which the extreme vertical motion was recorded. By these charts, we have been able to calculate that, in this particular car, the movement of cycles of shimmying for different air-pressures were as given in Table 4. The extent of the vertical motion of the frame with respect to the axle at the times of shimmy-

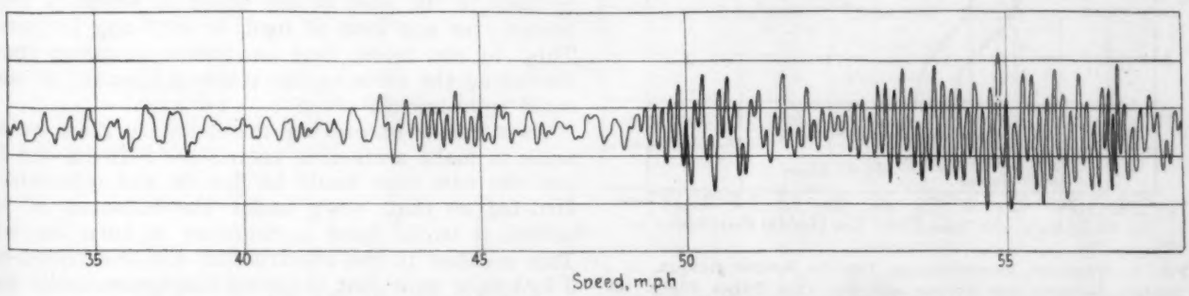


Fig. 2—A Sample Record Obtained with a 7.30-In. Balloon Tire

This Graph Was Taken when Driving over Smooth Asphalt Pavement That Was Free from Holes or Other Surface Imperfections. The Front-Wheel Load Was 1000 Lb. and the Inflation-Pressure Was 20 Lb. per Sq. In. It Will Be Noticed That Some Motion Between the Spring and the Frame Occurred at All Speeds. The Extreme Vertical Movement Indicates the Speeds at Which Shimmying Happened

ing was from 2.5 to 3.0 in. It is my observation that shimmying with given pressure and load on the wheels, can be depended upon to repeat at the same speed from time to time. My observations have reference to 8 or 10 different makes of automobile, as I have ridden in each of these kinds and have driven most of them myself.

In looking up references on front-wheel shimmying, I find that many theories concerning it have been advanced over a period of years, but that no one at the present time appears to be so well informed regarding this problem that he is able to prescribe successfully in curing the trouble. Although I do not consider that I am in a position to furnish the much desired answer, I am hoping that what little I am able to contribute will be helpful toward the solution at which somebody must finally arrive.

Some Effects of Shimmying

I should like to record what appears to me to be largely responsible for this unpleasant effect. First, I should say that, in all my observations, the high-speed-shimmying problem is not associated with cars having two-wheel brakes, but is confined strictly to cars having front-wheel brakes; and it is very clear to me that some features of design, necessitated by front-wheel brakes have produced shimmying.

Another aspect is the effect of low-pressure on the tires. The axle and wheel mass, which, by the way, is very much increased by the addition of front-wheel brakes, floats between two springs, and evidently the axle mass is thrown into violent agitation between these two springs because of a periodicity combination of the axle-mass and the reaction with the frame above. This periodicity combination I, personally, do not understand at all, but I wish to call attention to it, because plenty of evidence exists to the effect that it is present and is at the bottom of all the trouble. As we advance in mastering the shimmying problem, the understanding and mastering of this situation will be necessary.

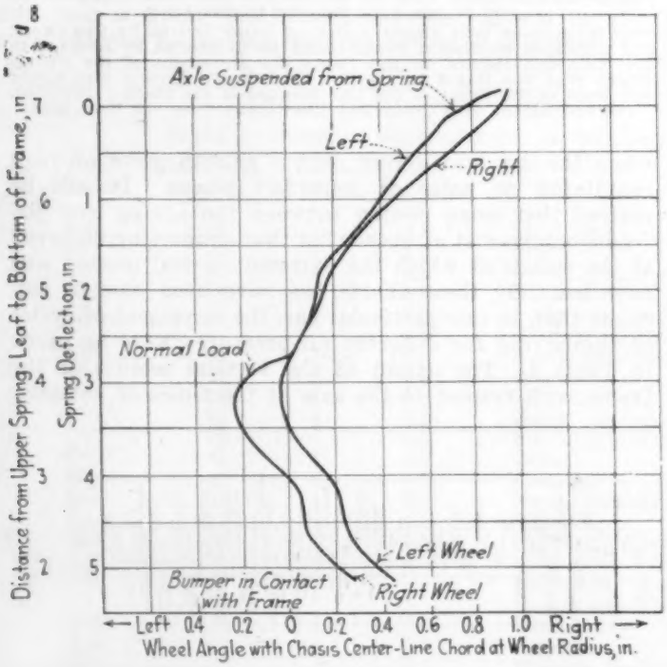


Fig. 3—Steering Interference Due to Spring Action
When Motion between the Frame and the Axle Takes Place, the Arcs Described by the Front End of the Drag-Link and the Up-and-Down Motion of the Axle around the Front-Spring Pin Do Not Produce a Straight Neutral Motion without a Turning Effect on the Steering-Wheel. The Chart Reproduced Herewith Shows Accurate Measurements of This Error

It is entirely probable that violent shimmying, in some cases, is the result of the pyramiding of forces. In contemplating the extreme violence of shimmy action, it is evident that some very great force must be at work somewhere in the system that makes the action so severe; and it is more than likely that some of this action is caused by the pyramiding of forces in proper periodic relation to throw the wheels violently from side to side.

Taking the thought that forces of considerable magnitude are at work to produce shimmying, I have tried to figure out where some of these forces might come from, and I believe that we can find three different sources; (*a*) the geometry of the steering-gear, (*b*) the angle of inclination of the king-pin and (*c*) the change in the velocity of the wheels.

Referring to the steering-gear linkage, I have found that, in most cars, the path of the ball connection of the steering-arm is not a truly neutral path so far as steering is concerned when movement between the frame and the axle occurs. In other words, the arcs described by the front end of the drag-link and the up-and-down motion of the axle around the front spring-pin do not produce a straight neutral motion without a turning effect on the steering-wheel. This can easily be proved on any automobile by fastening the steering hand-wheel securely, alternately compressing and releasing the front springs through the maximum possible spring-travel and measuring the steering effect on the front wheels. On one car that was under observation accurate measurements were made of this error. They are shown in Fig. 3.

Result of Action Between the Frame and the Spring

It is evident that if there is action, for any reason between the frame and the springs when the driver is holding the hand-wheel steady, the wheels must steer alternately to the right and the left. By referring to the chronograph chart reproduced in Fig. 2, it can be seen that considerable magnitude of spring motion occurred on the front end, and this, in my opinion, accounts for the alternation of the front wheels toward the right and the left. If this is true, anything that can be done to reduce the spring motion will tend to reduce the shimmying. We were able to do this by putting stiffer springs on the front end and by using rebound checks that were very tight. As a matter of fact, although this latter combination made a material improvement, the car still shimmied, so to carry the point still farther, we eliminated the front spring action between the frame and the axle by clamping the frame down tight, with the springs in the position of normal deflection. When this had been done, this car did not shimmy in the least at any speed at which it could be driven over any kind of road, or with any air pressure. This, to my mind, was conclusive evidence that, by correcting the error in the steering linkage, shimmying could be overcome.

As a means of proving this point further, we set to work to make a steering connection between the frame and the axle that would be flexible and otherwise constructed so that, when under the influence of spring action, it would have no tendency to turn the wheels. This resulted in the construction and the trying-out of a hydraulic gear that is shown diagrammatically in Fig. 4. The cylinders were duplicates and, as indicated, were constructed so that the car was steered by a hand-wheel in the ordinary manner. When this had been

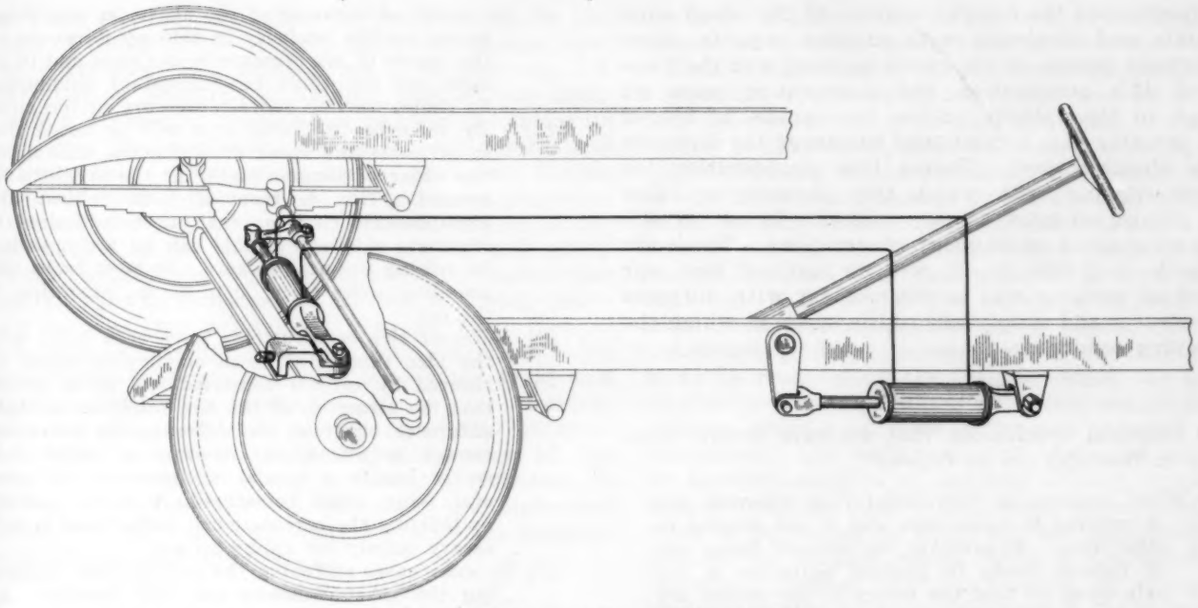


FIG. 4—A HYDRAULIC TYPE OF STEERING-GEAR
This Gear Was Designed To Provide a Steering Connection between the Frame and the Axle That Would Be Flexible and So Constructed Otherwise That when under the Influence of Spring Action No Tendency for It To Turn the Wheels Would Exist

tried out, it resulted in a 100 per cent reduction of front-wheel shimmying.

As a matter of fact, in the case of both blocking out the springs and with the hydraulic gear, the twitching of the hand-wheel was obviated as well. To my mind, hand-wheel twitching, which, as I indicated previously will be severely criticized by owners, is caused largely by an error in the geometry of the steering-gear.

INCLINATION OF THE KING-PIN

I will now take up the inclination of the king-pin, by which I mean not the caster angle but the angle that the king-pin makes with the vertical when viewed from the front. It was pointed out to me by S. R. Thomas, of the Jordan Company, that, because of the combination of this inclination with the caster angle and the wheel camber, the axle was not in its lowest position when the wheels were steering straight ahead; that when the tire is on and the drag-link is disconnected, a tendency exists for the wheels to turn in other directions, on account of the tendency of the axle to become lower. Under these conditions, it can readily be seen that with the axle mass throbbing up and down, as it does, especially when one end goes up and the other down at an extremely large number of cycles per second, the effect will be a tendency to throw the wheel around so that the axle can take the lowest position and consequently cause shimmying. If this effect of the inclination of the king-pin is as stated, and considering the fact that with two-wheel brakes the king-pin is inclined only slightly when viewed from the front, I am of the opinion that the preferable way would be to alter the design to make the king-pin vertical, if possible.

The extreme, alternately up-and-down, motion of the front axle, flattens the tire out or relieves it from its load even to the extent of possibly jumping off the ground. So far, no method has presented itself to us for measuring the up-and-down motion of the axle with respect to the pavement, but we know that it is of considerable magnitude. Consequently, the rolling radius of the tire must change considerably. In my opinion, the change would probably be from 8 to 12 per cent.

TABLE 5—RESULTS OF FRONT-WHEEL-WABBLE INVESTIGATION SHOWING SPEED AT WHICH VIOLENT SHIMMYING OCCURRED

Inflation-Pressure, lb. per sq. in. / Combination Tested	15	20	25	30	35	40
A	32	41	50	50	57	62 to 63
B	40 to 43	50 to 54	55	60	60 to 62	63
C		O.K. to 60	O.K. to 65	O.K. to 65	O.K. to 65	
D	33		48 to 50	50 to 53	58 to 60	60
E	35 to 40		50 to 55			
F	37 to 38	43 to 47	52	58	61	63
G			55	58	60	
H	37	43	50	55 to 57	62	Unsteady at 67
I	45 to 50	55	60	65	62	O.K. to 65
J	35	43	48 to 52	50 to 52	56 to 58	
K	38	40 to 53	50	55	57 to 59	60

Combination Tested	Details of Combinations Tested: Size of Tire	Number of Plies	Rim Width, In.	Balanced or Unbalanced	Deflection Rating, Lb. Front	Deflection Rating, Lb. Rear	Inflation-Pressure in Rear Tires, Lb. per Sq. In.
A	7.30	4	4½	Unbalanced	318	354	35
B	7.30	4	4½	Balanced	425	475	
C	7.30	4	4½	Unbalanced	No springs in front		35
D	7.30	4	4½	Balanced	318	354	35
E	7.30	4	4½	Wheels unbalanced about 1½ lb. each	318	354	
F	6.75/21	6	5	Unbalanced	318	354	
G	33x5	6	4½	Unbalanced	318	354	50
H	7.30	4	6	Unbalanced	318	354	35[a]
I	7.30	4	4½	Balanced	318	354	[b]
J	7.30	4	4½	Balanced	318	354	[c]
K	7.30	4	4½	Balanced	318	354	[c]

[a] Play taken out of steering-gear.
[b] Front brakes removed.
[c] King-Pin set forward at bottom about 2 deg.

This means that the angular velocity of the wheel must accelerate and decelerate with extreme rapidity, since the forward motion of the car is constant and the reaction of this acceleration and deceleration must go through to the spindle. Since the spindle is hinged about the king-pin, it must tend to change the direction of the steering-wheel. Taking into consideration the extreme rapidity with which this phenomenon takes place, the action must be very violent. In our experiments we made a great many observations. These are set forth in Table 5. It will be noticed that our method of working was to run the car with different air-pressures and simply record the speed at which the shimmying occurred.

Conclusion

The practical conclusions that we have drawn from testing in this way are as follows:

(1) Wheel balance is very helpful in relieving the shimmying in some cars and is not helpful in other cars. Apparently, the wheels' being out of balance tends to produce agitation in the axle mass, so that the errors of car design are exaggerated in such a way that shimmying is produced

(2) I have proved definitely that the section or the size of the tire has no relation to shimmying. In other words, any shimmying car will shimmy on high-pressure tires as readily as on balloon tires, provided the air pressure is as low in the high-pressure tires as it is in the balloon tires

(3) As a sort of converse of the above, in any shimmying car the tendency to shimmy is caused by the degree of air pressure in the tires and in all cases the car could be relieved of shimmying by simply raising the air pressure in the tires. By referring to Table 5, it will be noted that in all cases the speed at which the shimmying was observed became higher as the pressure increased. This is true of both balloon and high-pressure tires, so that, if it is desired to eliminate shimmying, this can be accomplished by raising the air pressure. In most cases this pressure varies from 30 to 45 lb., according to the car

(4) Different tire constructions have been tried with the idea that relief from shimmying might be secured by certain construction. It is known that the structure of the tire produces a slight difference but that the difference is not great enough to afford any measure of relief that would justify a special construction. In general, when relief is secured, it comes entirely by building the carcass much stiffer than is necessary merely for riding on air

(5) In some cases stiffening the springs and tightening the rebound-checks are very helpful. As indicated above, carrying this to the extreme of blocking out the springs altogether on the front will positively eliminate the shimmying. This, however, could not be resorted to in practice and is only mentioned to indicate the tendency

(6) The steering-gear from the wheels to the hand steering-wheel must have little or no backlash

CORRECTION OF BALLOON-TIRE SHIMMYING

BY R. B. DAY[2]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

SHIMMYING was noticeable before four-wheel brakes began to be used, but since that time the trouble has been greatly increased. Two kinds are distinguishable; (*a*) low-speed shimmying, a violent wabble of the front wheels about the king-pins, without a bouncing of the front axle, and (*b*) high-speed shimmying, a severe bouncing of the front axle during which one hub is up while the other is down. This occurs at somewhat higher tire-pressures and at high car-speed. Believing that both forms are not correctible by changing the design of the tire, and are only slightly affected by changes in the steering-gear, efforts were directed toward prevention rather than correction. A dashpot, attached between the front axle and the front-wheel brake-housing was found to prevent all low-speed and a large part of the high-speed shimmying, without appreciable resistance to steering, and also to be effective in removing "road-shock," "whip-back" from the steering-wheel, and even the rotational vibration that accompanies ordinary driving. The door-check type of dashpot avoids many undesirable features common to other types. To be effective, all air must be religiously excluded, all joints must be tight, all fits must be good, all moving parts must be non-flexible and the liquid used must be non-freezable.

EVEN before the arrival of four-wheel brakes, tire companies observed that balloon tires showed a tendency to shimmy. Although this trouble was known to tire users, it was not then common enough to be important. With the advent of four-wheel brakes, however, the complaints about balloon tires' shimmying greatly increased. The trouble is now so serious that a correction must be found.

First, we had to find out what shimmying is. It did not take long to observe that two distinct effects are produced. These we proceeded to call low-speed and high-speed shimmying. The latter is sometimes called "tramping."

Low-speed shimmying is a violent wabble of the front wheels about their king-pins. This wabble is not accompanied by bouncing of the axle. It commonly occurs with low tire-inflation and at moderate car-speed. It is possible to pass out of the low-speed shimmying range by using impracticably low or undesirably high inflation-pressures. Some reduction in this sort of shimmying can be obtained by stiffening the tire carcass. It is doubtful, however, if the gain is worth the effort. Friction, though undesirable, is probably the simplest means of eliminating this effect.

High-speed shimmying is a very severe bouncing of the front axle, when one hub is up while the other is down. It is usually accompanied by a wheel wabble similar to that in low-speed shimmying. It occurs at somewhat higher tire-pressures and at high car-speed. It is a resonance effect between the natural vibration-period of the tire with its load and the period of the front springs with their load. Chiefly, because of the high speed at which it occurs, this is the more serious form of shimmying.

We came to believe early that both forms of shimmying are inherent in large size and low pressure; that is,

[2] Research department, Goodyear Tire & Rubber Co., Akron, Ohio.

that they are not correctable by modifications in the design of the tire. To be sure, changes in design have some effect but the differences are of degree only. A ballon tire is primarily a toroidal body of air under moderate pressure. Nothing can be done to change its character. The enveloping casing is very flexible and relatively thin. This casing can be made less flexible and thicker but neither change can mask the properties of the enclosed toroid of air. Next, we come to believe that changes in the steering-gear would be only partly effective unless they were accompanied by undesirable features, such as considerable friction, or unduly heavy parts to eliminate flexibility. We proceeded then to work toward prevention rather than correction. We found that a dashpot attached between the front axle and the front-wheel brake-housing or the steering-knuckle could be made to prevent all of the low-speed and a large part of the high-speed shimmying; all this could be done without any appreciable resistance to steering. To complete the prevention of high-speed shimmying we found that unusually effective snubbers or stabilators were required.

Use of the Dashpot

Aside from its use in preventing shimmying, we found that a dashpot is very effective in removing "road-shock" and "whip-back" from the steering-wheel. If a front wheel drops into a pot-hole, or if a front tire becomes flat, the hand does not feel any jerk. Even the "fine-grained" rotational vibration that accompanies ordinary driving disappears. For one who drives much, this feature is very important.

The dashpot need be effective only when the car is running straightaway. In turning corners, it is not needed. This allows the cutting of bypass ports in the cylinder walls in such a manner that when the piston has moved a small fraction of its stroke to one side of the middle position, the liquid passes around the piston without offering further resistance. As a rule, we have found such bypasses unnecessary. The dashpot on our demonstration car does not have them.

Our company does not take the position that a dashpot and stabilators offer the only means of preventing shimmying. We propose them, however, as one method. Also we point out, as a very valuable incidental feature, the disappearance of road shock from the steering-wheel.

The dashpot that we have on our demonstration car has some very undesirable features. Each stroke of the piston-rod carries grit into the stuffing-boxes. Each time a load is placed on the connecting-rod the stuffing-boxes must resist liquid under pressure. In consequence, a slow leakage of oil occurs, so that every 300 or 400 miles we must use an oil gun to drive out the trapped air. This type of dashpot has no oil reservoir to replace automatically the lost or evaporated oil. All these features are met by the door-check type of dashpot.

Air must be religiously excluded from all dashpots; all joints must be tight; all fits must be good; all moving parts must be non-flexible; and the liquid used must be non-freezable.

The Discussion

R. B. Day:—Mr. Hale has made a great many statements and, in practically every case, my own observations check his. Was the number of cycles per second, cited by Mr. Hale, 50 complete cycles or only one-half that number?

J. E. Hale:—Fifty complete cycles.

Mr. Day:—I am convinced that the trouble is not in the tires. I believe that 50 per cent of the trouble can be avoided by using dashpot and stabilators.

E. J. W. Ragsdale[5]:—The interest of the company that I represent in shimmying has always been an incidental one; the company is in no wise interested in the manufacture of front axles, tires, or, in fact, anything having a direct bearing on the problem. But because the type of disc wheel manufactured by our company lends itself to the housing of front-brake mechanisms and a certain form of steering-knuckle construction, the company early became identified with front-wheel-brake development in America. In developing disc wheels in conjunction with front-wheel brakes, we, like many others, encountered the shimmy problem. It was realized that little progress could be made along the lines to which we hoped to confine the argument unless we offered some solution of shimmy behavior, at least in the cars prepared as demonstrators. Our embarrassment continued even after an apparent solution of our own shimmy troubles had been found, inasmuch as engineers became more interested in the manner by which this had been accomplished than in the peculiar selling points of the wheel. It is, therefore, through this combination of circumstances that our company became interested in the shimmy problem as such.

As Mr. Hale has indicated, the shimmying characteristics of no two cars are alike. In fact, it has been our experience that the same car would not perform consistently under conditions seemingly alike.

Our starting-point was with the vertical, rather than the inclined, central-pivot type of axle. You will note how such a structure lends itself peculiarly to the outwardly dished type of disc wheel. The vertical pivot alone did not stop shimmying. It has been our experience, however, that a shimmying condition can be restrained by a vertical pivot, whereas we have been unable to accomplish the same end with the more conventional inclined central pivot. It seems, therefore, that the vertical pivot must have a pronounced advantage.

The first big step, aside from relocating the pivot, was taken in connection with the steering-knuckle arm. It has been found in a number of instances that this arm, particularly when it is of the goose-neck type, acts as a spring, alternately storing and releasing such energy as may be put into it by the flopping of the front wheels. By changing the section of the arm and reducing its tendency to spring, we found that, in most cases, shimmying could be eliminated from a vertical-pivot axle; but we also found that in no case were the conditions materially improved with the inclined pivot.

It would seem that the steering of the front wheels would neither raise nor lower the front end of the car with any reasonable degree of pivot inclination. This is theoretically true so long as we have line contact with the road. But we have no such condition. With balloon tires, the width of contact is 3 or 4 in., and under this condition the effect in steering would be the same as if the axle were given several degrees of rake. Therefore, when some incident of the road causes a side movement of the front wheels, the weight of the car assists in bringing them back to the normal position and the momentum then carries the side movement in the opposite direction. The condition becomes not unlike that of a pendulum. This may be the reason that our efforts to restrain the shimmying in the case of the inclined pivot have been without results.

Speaking of a vertical central pivot is a comparative rather than an exact statement. The off-tread condition

[5] M.S.A.E.—Edward G. Budd Mfg. Co., Philadelphia.

should obtain here as in the case of the inclined pivot. This allows the taking-up of springing and lost motion in the same direction and makes for stability on the road. Although we have experimented with an exact central location, the results have not been happy, especially after lost motion has been introduced.

In attacking any particular problem of balloon-tire shimmying, it is well first to bear in mind that the balloon tire lacks any sense of direction. It would as soon go sidewise as forward. In fact, it would prefer to do so. A balloon tire rolling over the road seems to build up a fold in front of itself and, being of a lazy disposition, prefers to go round this fold rather than climb over it. This makes for instability from the beginning. The probability of ever correcting this tendency at the source is very remote and research along the lines of restraining it will be more profitable.

Another peculiarity of the balloon tire, inasmuch as the distance from the point of contact with the road to the center of the spindle is a constantly fluctuating one, is that the tire seems to absorb an obstacle much as does an amoeba in taking food. This means that the distance from the spindle to the point of contact may vary from 11 to 15 in. within a very short period of time.

Now, examine the geometry of the inclined and the vertical types of pivot. In the case of the inclined pivot, a moment-arm of more than 1 in. is produced and such tractive resistance as exists becomes operative at the end of this arm. In the case of the vertical pivot, the moment-arm is subject to practically no variation, regardless of the condition of the tire. This, we feel, is another possible contributing cause of wheel shimmying.

This condition again interests us in connection with the question as to what happens in the case of a front-wheel blow-out with balloon tires. In demonstrating this point, we used a car equipped with a vertical-pivot axle and 6.20-in. balloon tires. A shotgun was tied across the front bumper-supports and, while the car was driven at 45 m.p.h. over a fair macadam road, was fired, putting a heavy load of duck shot through the tire. The report and the complete deflation of the tire were almost simultaneous. The tire was almost off the wheel by the time the car was stopped. The point of interest is that, although the driver had only one hand on the wheel, no particular effort was required to hold the car on the road, even after the application of all four brakes. Very able drivers have tried this experiment at even higher speeds. The question has not been fully answered, however, for they were drivers of unusual ability and expected the trouble. In the case of the car that we demonstrated, the driver need not have his hands on the wheel at all, provided a fairly even and uncrowned road is selected for the experiment.

Here, with the point of contact changing through some 6 in., no uncomfortable condition arises. In the case of an inclined pivot, with some 9 or 10 deg. of inclination, a turning-moment of approximately 4 to 6 lb-in. becomes effective on one wheel. This is likely to make itself felt unless the steering reduction is extremely high.

Another point of interest in our studies of shimmying is that we have found that the best results are obtained by cutting down the amount of conventional front-wheel toe-in, that is, with balloon tires. The best results are obtained with from 1/16 to ⅛-in. toe-in at a point 10 in. from the ground.

Summing up the advantages that we believe to be peculiar to the vertical type of axle, we find these to be four, namely:

(1) An easier steering-condition with balloon tires, other considerations remaining the same
(2) Less sensitiveness to poor front-wheel-brake equalization, especially with balloon tires, when the spring height is subject to fluctuations
(3) A greater degree of security, in the case of front-tire blowouts
(4) The bringing of the inherent shimmying tendencies of balloon tires within a controllable range

I should like to invite attention to the lack of an exact nomenclature by which we can make ourselves understood. Even the term "shimmy" seems to have little in common with its original meaning, except, possibly, that both meanings are considered rather wicked.

The front wheel movement, or wabble, generically termed "shimmy," usually consists of a side flopping of the front wheels, or a vertical movement of these wheels, or a combination of both. In our own work, we have, with perhaps more picturesqueness than scientific exactness, termed the side flopping, "gold-fishing," and the vertical movement, "tramping." No term adequate for describing the combination of these two movements has as yet suggested itself.

R. J. FITNESS:—Did the use of hydraulic gear overcome tramping?

MR. HALE:—It eliminated both the shimmying and the twitching of the wheel. It was the most satisfactory job that we could ask for.

O. M. BURKHARDT[1]:—What impresses me most after today's demonstration is that the tiremakers still have the impression that balloon tires will not shimmy. They begin to admit that they must be properly inflated. Inflation-pressures have, of course, been left entirely to the liking of the owner. We all are agreed, however, that 10,000,000 automobiles have run on high-pressure tires and that the cars that could lay claim to being well built have given, up to the last year, remarkably little trouble so far as shimmying is concerned. Immediately after the introduction of balloon tires, the cars that had been notably free from shimmying began to have trouble with the low-pressure tires, not only in the hands of engineers, but in the hands of customers, to whose discretion the control of the inflation-pressure was left optional. In the face of this fact, we must acknowledge that the public will allow tires carrying 60 lb. to run down to 30 lb. of air pressure and, under the same influence, namely, neglect, they allow tires that need 25 lb. of air pressure to run down to 12 lb. This will explain why, with the introduction of balloon tires, shimmying has suddenly become a general complaint.

It is apparent that friction will help to reduce shimmying. This is, of course, what we have been expecting. Balloon tires are noted for their instability. This characteristic is particularly disadvantageous so far as lateral stability is concerned. With the balloon tire has appeared a new degree of freedom of oscillation in motor-car dynamics, because a car equipped with balloon tires is remarkably free to oscillate about a vertical axis through the center of gravity. It is very easy to demonstrate that, when a car is equipped with balloon tires and the front fenders are pushed over and pulled back, a transverse oscillation is established and the rear end begins to oscillate in sympathy with the front end, though in the opposite direction, a result that conforms with the oscillation about the center of gravity previously mentioned. This transverse motion has considerable influence on the geometry of the steering, par-

[1] M.S.A.E.—Consulting engineer, Pierce-Arrow Motor Car Co., Buffalo.

ticularly insofar as the distance between the projection of the center-line of the king-pin on the ground and the center of tire contact with the ground is concerned. With this distance changing with the transverse motion, we have a variation in the lever-arm, which in my estimation is the main cause of shimmying.

A. J. BAKER[5]:—The question of the number of sizes of balloon tires was discussed a year ago in New York City. The number of balloon-tire and rim sizes seems to be becoming greater instead of smaller. I think it was stated that four-ply tires were entirely satisfactory from the users' standpoint. My experience has been to the contrary, however. The puncture figures given by Mr. Hale do not agree with our experience. The pressures quoted throughout these tests have been very low. I gather that the tire manufacturers are recommending somewhat higher pressures. The average balloon tire does not seem to hold the pressure. I do not find that balloon tires remain at 20 lb. air pressure. I believe that the plan mentioned is the best, that is, to begin with high pressure and let it work down until it gives trouble, then pump the tire up again. We shall undoubtedly have shorter-lived tires, if we have overinflation, but I don't believe that it can be avoided. I have gathered from conversations I have had with users that, unless we take steps very soon to avoid the trouble we are having, balloon tires will receive a setback.

Mr. Hale mentioned the backlash in the steering mechanism. On an experimental car that I have been driving, I have found that a distinct improvement has been produced insofar as the road shock on the steering-wheel is concerned, by allowing more backlash on the steering-wheel.

Mr. Hale spoke of the benefits of stiffer front-springs. In the matter of reducing high-speed tramping, I have found precisely the opposite to be the case. Front-springs that were not stiff greatly reduced high-speed tramping. In considering the tests made by Mr. Hale, blocking up the space between the spring and the frame will give an additional stiffness to the front end of the car. In other words, you must lift up the whole front end and not merely one side. If you wish to find whether stiff springs will help, I believe that stiffer springs, not wooden blocks, should be used. I believe we must use longer front-springs soon. Did any vertical wheel-movement occur in the hydraulic steering-gear? If so, was it with free springs or with the blocks?

MR. HALE:—The hydraulic steering-gear was used with the springs free; no vertical wheel-movement was apparent.

MR. BAKER:—Mr. Ragsdale said that he obtained great improvement by stiffening the steering-arm. We found no difference by doing so. We found no effect from balancing or not balancing the wheels. In our experimenting, we have been able to overcome the goldfishing at high speed and still retain the tramping. Conditions were different on each of the seven different makes of car that we tested.

F. F. CHANDLER[6]:—Mr. Hale is correct in his statement that shimmying action is induced by the tramping of the front axle. I have found this to be the case in cars that I have investigated. I have cured the tendency by using stiffer springs and various kinds of shock-absorber. I also have checked Mr. Hale in his statement that the hard steering of balloon tires is a function of tire pressure and practically nothing else. I spent a whole day in getting some basic information with reference to the moment necessary to twist the front wheels of a vehicle when the vehicle is at rest, and on three different kinds of road, namely, asphalt, brick and hard gravel. In making these tests I used tire-pressures ranging from 35 to 65 lb. per sq. in. for high-pressure tires and from 15 to 35 lb. per sq. in. for balloon tires. These results therefore give the maximum moment necessary to move the front wheels of the car when the vehicle is at rest. It is, of course, well known that, when the vehicle is in motion, the moment decreases very materially; but it is supposed that, even so, the moment is a function of the tire pressure.

I plotted the results of these tests and found that the moments represented by the curves increased when the tire pressure was reduced from 65 to 35 lb. per sq. in. Beginning at 35 lb. per sq. in., the balloon-tire curves practically pick up the ends of the high-pressure-tire curves and continue down in an even sweep. This shows that Mr. Hale's statement is correct. The curves also show how the moments change, not only for different kinds of road, but for different loadings of the front axle. In these tests, I first took the car-weight alone in securing the moment, then added 100 lb., and finally 200 lb. to the front-axle load to determine how much the steering-moment would be increased under these conditions. It is interesting to know that the minimum moment for gravel-road conditions with 65 lb. per sq. in. of air pressure was 1300 lb-in., that the maximum moment was secured on a brick pavement with a 200-lb. additional axle-load with 15 lb. per sq. in. of air pressure, and that the moment under these conditions was 3460 lb-in. These moments, when translated into drag-link forces on this particular car, ranged from 150 to 435 lb.

Comparisons were made to show how much increase in the moment was produced by substituting balloon for high-pressure tires. This was observed at three points. For instance, with high-pressure tires at 65 lb. per sq. in. and balloon tires at 35 lb. per sq. in., the increase was 25 per cent; with high-pressure tires at 50 lb. per sq. in. and balloon tires at 25 lb. per sq. in., the increase was 53 per cent; with high-pressure tires at 25 lb. per sq. in. and balloon tires at 15 lb. per sq. in., the increase was 69 per cent. I figure, therefore, that the average increase, covering the range of pressures we find in practice, would be an average of the above results, or 49 per cent.

Another thing that is not generally known is the amount of steering-moment with a front axle that has not been lubricated for a long time, as compared with a front axle that has been lubricated. Results in this connection were obtained by mounting the front wheels of the vehicle on a ground-steel plate and interposing a handful of bearing balls between this plate and a correspondingly ground plate placed upon the road. In a certain car provided with thrust ball-bearings, in steering-knuckles that had not been lubricated for a long time, the decrease in the steering-moment, immediately after fresh lubricant had been applied, was 58 per cent.

Steering-gear manufacturers will be forced to increase the overall efficiency of steering-gears. This can be done by good design and better workmanship. Cars of the future must overcome the very objectionable "road-fight" that now exists in many models. Furthermore, the best steering-results, in my opinion, can be secured only in a system that has the proper righting effect after turning a corner. It will take very little friction in the steering-column to prevent a car from straightening up

[5] Production department, Willys-Overland Co., Toledo.

[6] M.S.A.E.—Chief engineer, Ross Gear & Tool Co., Lafayette, Ind.

or righting itself, so that this point must be looked after very carefully.

The steering-gear plays a large part in the question of road-fight. This is, however, a subject that is worthy of a paper by itself, to introduce the subjects of the critical angle of friction, the form of the surfaces in contact in the gear and lubrication. Recent observations show that this depends somewhat upon the frequency of the alternations of stress in the drag-link. I am preparing data on these subjects, but time will prevent a further discussion of them now.

HENRY MARLES[7]:—One or two things particularly interested me in the demonstrations we have seen. I think it has been shown that the action of the reach-rod or drag-link is largely responsible for the *starting* of shimmying, due to the front end of this rod rising and falling in an arc contrary to that described by the front axle in its movement up and down.

The proof also was ample that the dashpot as fitted to the demonstration car did prevent this shimmy from becoming objectionable, but I also think the shimmying can be controlled by a suitably constructed steering-gear having no backlash and a sufficiently low ratio, say 15 to 1, to give it the necessary amount of irreversibility. It is along these lines that we have been working and I fully believe we have succeeded in producing such a steering device.

L. H. POMEROY[8]:—If we shackle the front spring at the front end, it is perfectly easy to get two arcs that do not intersect. You will say, If it is so simple, why has it not been done? That is just the reason it has not been done.

Another point I would commend to the shimmy experts is the case of a racing motorcycle, which suffers from the disease known as "speedman's wabble." Here there are no springs, drag-links, pitman arms or steering-ball locations to deal with. Yet a phenomenon arises that in my opinion is analogous to that of shimmying. A mathematical analysis of speedman's wabble indicates that under some circumstances the various factors affecting it so compound themselves as to cause a periodic action that tends to die out, while with other combinations any initial disturbance becomes increasingly greater. Therefore, some definite fundamental cause or causes seem possibly to be connected with the gyroscopic action of the front wheel, which, if susceptible of isolation, might lead to a definite understanding of this ghostly quantity.

J. F. PALMER[9]:—I have a car that shimmies at slow speed. I have never believed that this is caused by the tires. Low-pressure tires do not make the shimmying worse. Engineers have built their cars for high inflation-pressures and the users have found that they get comfort and a longer life from a car with low-pressure tires. I also drive a car that I cannot make shimmy. It steers so easily that I can steer it with one finger and the thumb. I have had both 6.20 and 7.30-in. tires on this car. The fact that some cars do not shimmy or tramp proves conclusively that shimmying can be eliminated and that shimmying is not due to the tires. It seems to me that we are wasting considerable effort and time in pursuing a ghost. The solution is to be had and engineers must go after the problem and solve it.

R. D. BELDEN[10]:—We have been unable to produce shimmying on any of our test-cars. We have used all sizes of rim and of tire and have never been able to produce shimmying. After the demonstration this afternoon, however, it is apparent that such a thing as shimmying exists. The dashpot may be a solution.

MR. HALE:—In the case of low-speed shimmying on cars having front-wheel brakes, we have been able to overcome the trouble in practically all cases by removing the backlash in the steering linkage.

Mr. Baker has intimated that some persons are losing interest in balloon tires. He must have a source of information with which I am not familiar, because we, as tire makers, cannot subscribe to that sentiment. The mention of punctures certainly is not an element of magnitude, because, in all the tires we have sold, puncture complaints are lacking.

I take the positive position that balloon tires are giving, and can be expected to give, good service with less trouble than can high-pressure tires. I cannot conceive of their having a setback. If we judge from the attitude of the public toward low-pressure air, we must have balloon tires, because they are the only kind of tire that a tiremaker can produce with the expectation of obtaining good service.

[7] Gemmer Mfg. Co., Detroit.
[8] M.S.A.E.—Aluminum Co. of America, Buffalo.
[9] M.S.A.E.—Consulting engineer, Hewitt Rubber Co., Buffalo.
[10] Technical manager, Dunlop Tire & Rubber Corporation, Buffalo.

AN ARCHITECT'S FANCY

IN New York City all rail movement might be placed underground, the street level being dedicated wholly to wheel traffic and increased by widening the streets laterally until they spread under the facades of the existing buildings. Pedestrian traffic should be lifted into galleries or into second-story arcades, with light bridges thrown over the streets to connect these elevated sidewalks. I might describe the result in this way: A city with arcaded sidewalks, arcaded within the building lines, but one story above the present street-level; bridges at all the corners, so that pedestrians could move through the surface of the city, where this was, in effect, undisturbed by traffic conditions, never having to cross the street where the motor vehicles are, or have any of the dangers that they have at present. Walking would become a very pleasant episode instead of a hazardous occupation, as it is now. You could enter this district and pass through the whole shopping zone, undisturbed by traffic. The traffic itself would be on the street level, and it could spread to any extent underneath the building. That gives you possibilities of an elastic growth, and you would have a city that might be called a modern Venice, in which would be canals, the only difference being that those canals would be filled with motor vehicles instead of with water; and as the pedestrians looked over the edge of these bridges, they would gaze upon the sun reflected in the palatial tops of the automobiles as they passed and have all the delights of Venice as it used to be hundreds of years ago.—H. W. Corbett, before the Conference on Regional Plan of New York City.

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Preparing and Loading Automobiles for Shipment

By B. R. Moore[1]

Production Meeting Paper *Illustrated with* Photographs

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

FIRST among the operations of car loading is the cleaning of the box-car after it is placed on the siding. This in itself is no small item. Sometimes it is necessary to cover the floor of the box-car with paper if the previous shipment has been lime, cement, plaster, coal, hardening compound or similar material, the dust of which is harmful to automobile finish. Often, the box-cars must be repaired. If the shipment is to pass over the desert land in the West, proper precaution must be taken to protect the car finish from alkali dust.

After passing final inspection, the automobiles are turned over to the traffic department, all gasoline is drained and the models are distributed according to consignments. Blocking, decking and loading devices are distributed at the same time. Tools, lamps and small parts are packed in cartons and distributed along with the automobiles. Upon arrival at the freight-car, each automobile is stripped in accordance with the plan of loading determined upon. Batteries are disconnected, water drained, springs clamped, open-car tops folded and stowed, windshields removed and packed in crates and nuts, washers and small parts put in a small bag securely fastened to each machine. If the cars are shipped one above the other, the wheels are removed and their bearings washed, greased and packed in small boxes. The engine oil is drained if the automobiles are "half-decked." Caution cards are attached in a prominent place to all closed-car shipments, giving instructions regarding the proper handling of the car when it is unloaded. A paper drip-sheet is placed under the oil-pan of all cars shipped double-decked or half-decked. Shipments are termed "double-decked" when both ends of the upper automobile are supported on wooden stilts in the freight-car to provide clearance for another automobile underneath.

In loading, the Dodge company arranges the supporting wooden members so as to place the entire resistance to shifting of the load on the rear construction of the automobile, as this is where it is best adapted to withstand the shocks set up in transportation. When a shortage of box-cars exists and it becomes necessary to load on flat-cars or gondolas, a steel tripod is used to support the end of each axle, since there are no sidewalls to which wooden supports can be nailed. A shipment is termed "half-decked" when only one end of the automobile is raised off the car floor, this usually being the front end, since the greatest clearance underneath is obtained in this way. The supporting members in this case are similar to those used under the rear axle of cars in a double-decked shipment. Cars loaded on the freight-car floor are fastened with metal straps running over the axles when disc wheels are used and by rope running through the wheels when wooden wheels are fitted. The wheels are chocked fore-and-aft with grooved blocks that fit the contour of the tire and keep the wheel properly aligned.

After loading, all shipments are subject to four distinct inspections. First, a traffic-department record is made of the engine number and the numbers of any detached parts. Second, a traffic-department inspector tests and approves all bracing and blocking. Third, a representative from the sales department inspects and records the condition of the cars and parts, rejecting items that will not pass inspection, and these must be replaced or repaired. Finally, a sales-department inspector makes certain that the items noted during the third inspection are taken care of; then he seals the car doors. After checking all inspection-records against assignments and bills of lading, the box-cars are carded and hauled away.

Crating automobiles for foreign shipment is described also. In a year, this company uses, for automobile shipment, more than 24,000,000 board ft. of lumber and 1,250,000 lb. of nails, as well as hundreds of miles of paper. Evidence of the care and thoroughness used in preparing cars for shipment by rail is given by the figures quoted, to the effect that only 4.1 per cent of the loss and damage account on 216 American and Canadian railroads for one year was charged against motor-car shipments.

SHIPMENT of automobiles from present-day plants has reached such enormous tonnage that the automobile industry is now among the few industries that provide an all-year business for the American railroads. Faced with an ever-increasing automotive production, the railroads have tried to keep the pace thus set by building an adequate quantity of rolling-stock, but it is easily understandable why heavier loading of the freight-cars, more "dense" or compact, has been considered seriously from the beginning and that, from this necessity, ways and means of motor-vehicle shipment have been developed that formerly were not considered possible. These include many devices for holding an automobile rigidly in a freight-car during transit and attachment of the shipment to any and every part of the railroad car that has even a semblance of rigidity. Further, much study has been devoted to meeting the special requirements of given localities to or through which the shipment must pass, not only in this Country but also abroad. And all this must conform strictly to certain rules that pertain to automobile loading, as stated in the Consolidated Classification and in the loading rules of the American Railway Association.

Procedure at the Plant

At our plant, we have 10 tracks devoted to the carload-lot loading of automobiles for shipment to points in the United States. Twice daily, as an average, a line of empty automobile freight-cars moves in on each of these tracks and moves out, loaded. Freight-car numbers are ascertained as soon as the empty cars are assembled in the railroad yards, because a prompt assignment of

[1] Supervisor of shipment, Dodge Bros., Detroit.

models to suitable cars and designation of the destinations is essential in preparing the vehicles properly for shipment.

Immediately following the placement of the freight-cars, their doors are opened and the cars are cleaned. An assignment of the type of load and how it shall be loaded, as well as special instructions, are marked on the freight-car door. If the car previously contained lime, cement, plaster, coal or hardening compound, for instance, a special order would be posted that the car floor be covered with paper after the car has been cleaned. Other special orders might be that small repairs be made to the car floor or, if the shipment is to cross the desert, as when in transit to California, that coverings be provided for protection against alkali dust. If a freight-car is not fit to be loaded, it is sent away empty.

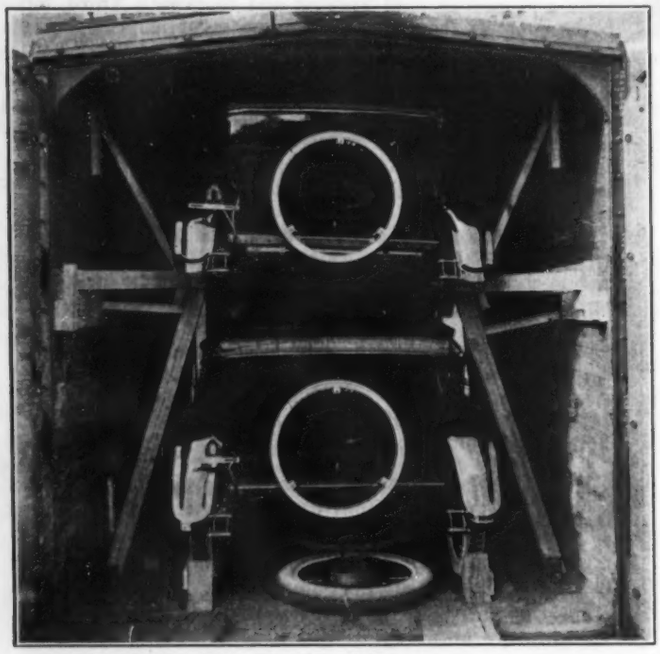

FIG. 1—FREIGHT-CAR DOUBLE-DECK SHIPPING-METHOD FOR AUTOMOBILES

Seen Through the Open End-Doors of the Box-Car, One Automobile Is Mounted Above Another as Shown. The Wheels of the Upper Vehicle Having Been Removed, 91 Board Ft. of Lumber Is Used To Support, Brace and Hold It in Position During Transit

Automobile loading for rail shipment is unlike other loading in that all the holding devices must be attached to the freight-car floor or walls and be capable of holding in place a bouncing 1 to 2-ton vehicle. It is made even more difficult by the fact that in some forms of loading the vehicle weight rests on pneumatic tires. The cost to the Dodge Company of freight-car preparation is more than $1,000 per month.

SHIPPING METHODS

After the automobiles are turned over to the traffic department by the department that gives them their final inspection, the various models are distributed to the freight-cars to which they have been assigned and all gasoline is drained from the tanks. The proper distribution of loading, decking and blocking devices is made at the same time; also, of small parts, lamps and tools that have been packed in cartons to be shipped with the vehicles.

At the freight-car, the machines are stripped, attention being given to the position they are to take in the car. This includes such details as disconnecting the batteries, draining off water, clamping the springs, crushing open-car tops and turning them and tying them down and pulling out windshields and packing them in crates. Keys, nuts, washers and all small parts are put into cloth bags and fastened securely to the machine to which they belong. If the shipment is to be "double-decked," wheels are pulled, the bearings washed, greased and packed in small boxes, and the clutch is released. If the "half-decking" method is to be used, the lubricating oil is drained off.

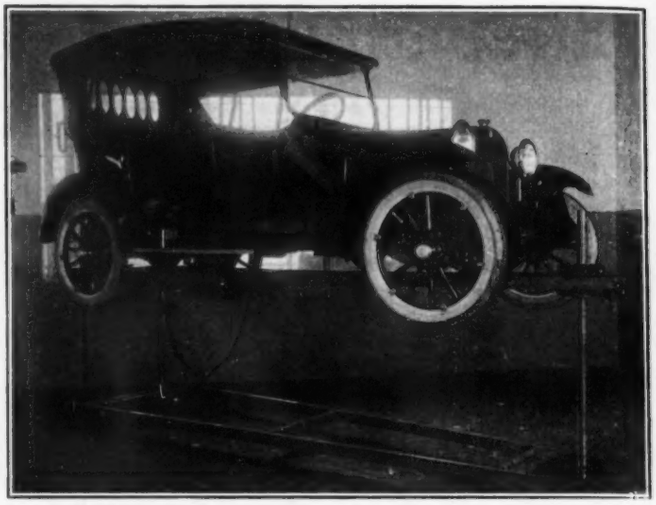

FIG. 2—DEVICE FOR RAISING AN AUTOMOBILE INSIDE A FREIGHT-CAR

Power Is Supplied by an Electric Motor through Selective Gears That Enable the Front or the Rear of the Automobile To Be Raised or Lowered as Desired, To Be Held at Any Position or Both Front and Rear To Be Raised or Lowered Simultaneously. When Being Raised, the Automobile Travels on a Level until the Rear End Reaches the Proper Height; Then, as the Front Needs To Be Higher than the Rear, the Gears of the Hoisting Device Are Shifted and the Front End Travels Up Farther. The Operation Requires Less Than 1 Min. The Process Is Reversed for Unloading

Caution tags are posted in conspicuous places to aid in protecting closed shipments while in transit; warning cards and instructions in regard to accepting delivery are included with each shipment. Whenever an automobile is double-decked or half-decked, a paper drip-sheet is placed under the oil-pan of each engine to pre-

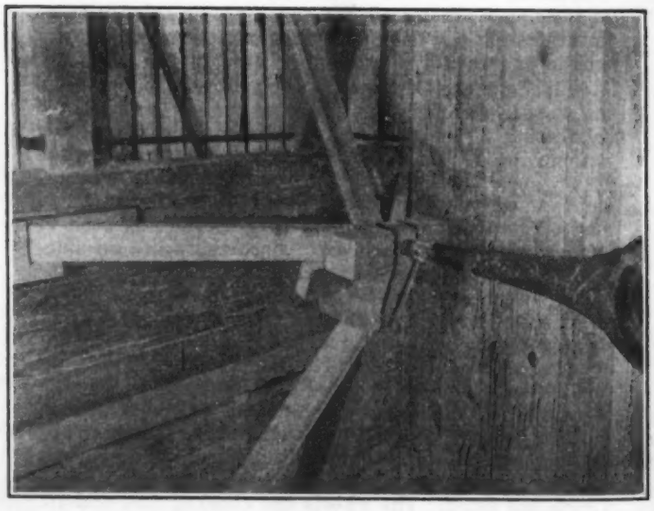

FIG. 3—WOODEN SUPPORT AND BRACING FOR DOUBLE-DECK SHIPMENT

Used Inside Box-Cars to Support and Hold One Automobile above Another by Its Axles

vent oil from soiling nearby shipments or dripping on other shipments underneath.

Double-Decking

When both ends of an automobile are raised on wooden supports in a freight-car to provide clearance for another automobile underneath, the process is termed "double-decking." Three chain-falls and grab-hooks are used ordinarily to raise the vehicle to the height desired and to hold it there while the decking supports are fitted into place and fastened securely. The falls are attached to the carlines or eye-bolts on the top belt-rail of the

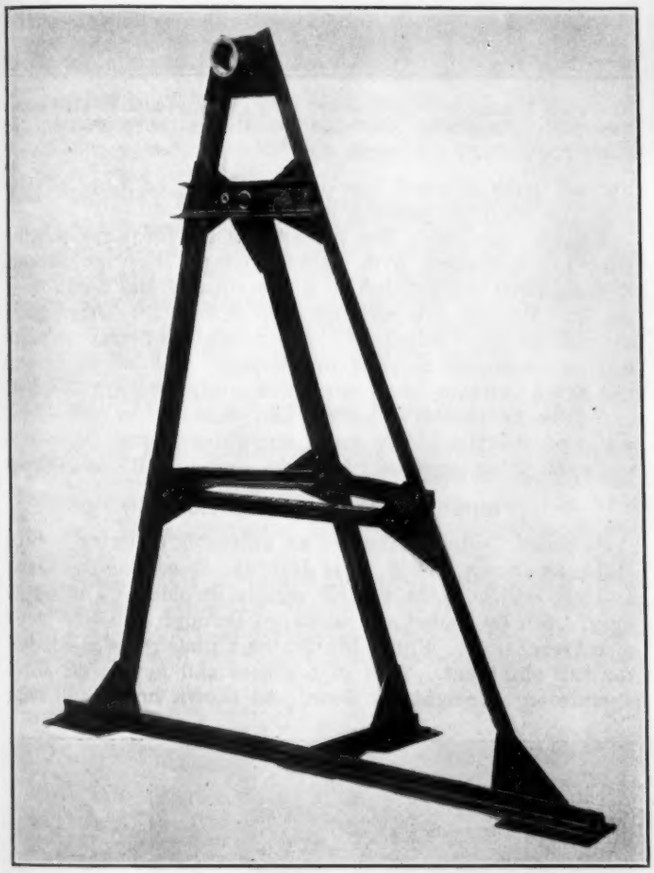

Fig. 4—Steel Standard for Double-Decking Automobiles on Railroad Flat-Cars

When No Side-Walls Are Available, as on Flat-Cars, Double-Decking Is Accomplished by Mounting These Supports on the Floor of the Railroad Car. The Standards Obviate Scaffolds That Otherwise Would Be Necessary, Are of "Knock-Down" Type and Are Returned to the Shipping-Point after Reaching Their Destination, Usually in Two Bundles, Nested, at the Fourth-Class Rate

freight-car, the grab hooks to the automobile frame near each rear spring and to an adapter-pin in front which screws into the front engine-support.

Looking through the open end-doors of the box-car, Fig. 1 shows how one automobile is mounted above another. The wheels of the upper vehicle having been removed, 91 board ft. of lumber is used to support, brace and hold it in position during transit. One important railroad has eliminated carlines or rafters in new automobile freight-cars and has substituted eye-bolts in the top belt-rail. This is good practice, because it provides greater overhead clearance. The freight-cars are 8 ft. 8 in. high, inside.

Another means for raising an automobile for decking purposes is shown in Fig. 2. Power is supplied to this

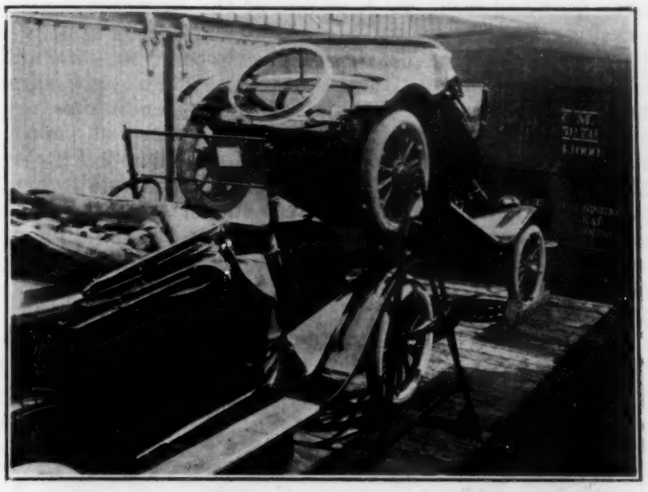

Fig. 5—Method and Density of Loading of Automobiles on Railroad Flat-Cars

Steel Standards, Similar to Those Illustrated in Fig. 4, Are Used To Raise the Rear End of the Forward Vehicle in the Manner Shown, Its Front Wheels Being Held by Blocks That Are Accurately Fitted and Securely Fastened

device by an electric motor through selective gears that enable the front or the rear of the automobile to be raised or lowered as desired, to be held at any position or both front and rear to be raised or lowered simultaneously. When being raised, the automobile travels on a level until the rear end reaches the proper height; then, as the front needs to be higher than the rear, the gears of the hoisting device are shifted and the front end travels up farther. The operation requires less than 1 min. The process can be reversed for unloading.

In providing against horizontal movement of the shipment, we concentrate the entire holding-stress on the rear construction of the automobile, as it is there best adapted to withstand the shocks incurred in transportation. By dividing the strains throughout the freight-

Fig. 6—Blocking Used for Automobiles Equipped with Balloon Tires

For Shipment, Balloon Tires Are Inflated to a Pressure of Say 55 Lb. per Sq. In. and Are Blocked in the Manner Shown. Dealers Are Instructed To Deflate the Tires upon the Arrival of the Shipment. Springiness during Transit Is Thus Minimized. The Blocks Are Fitted to the Tire Contour Very Accurately and Aligned Carefully To Prevent Chafing and Damage of the Side-Walls of the Tire; They Must Not Extend Over the Side-Walls, As These Must Be Free from Contact with Anything

car floor and walls, we have one of the strongest double-decking systems known.

Fig. 3 presents details of the wooden support and bracing used inside freight-cars when double-deck shipments are made. The axles of the upper vehicle are supported by the timbers, which are braced as shown. Fig. 4 illustrates a steel standard for double-decking or half-decking automobiles on railroad flat-cars which have no side-walls. These steel supports are mounted on the floor of the flat-car and obviate the building of scaffolds that otherwise would be necessary. They are of knock-down type and are returned to the shipping-point after reaching their destination, usually in two bundles, nested, at the fourth-class rate. They are used

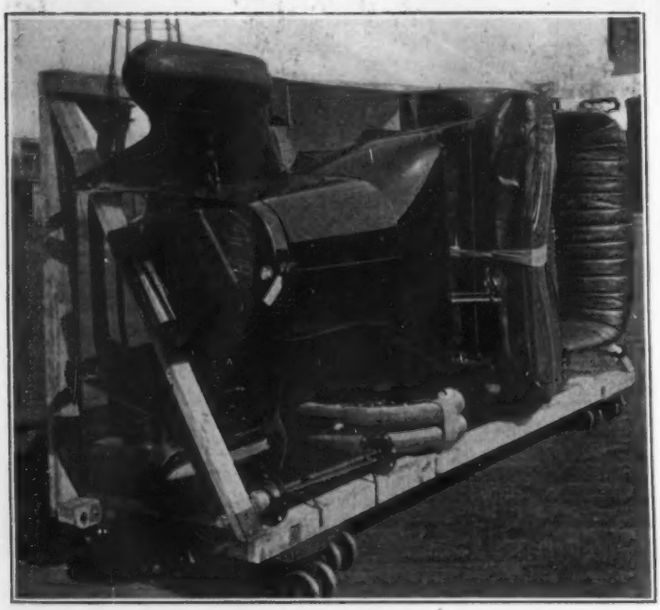

FIG. 7—SO-CALLED "SIDE-LOADING" OF AN AUTOMOBILE FOR RAIL SHIPMENT
Designed To Occupy the Minimum of Space and Yet Hold the Vehicle Rigidly in Place. The Car Can Be Loaded and Unloaded through the Side Door of a Freight-Car

also for shipments transported on railroad gondola cars, and can be attached to or mounted on all-steel flooring. This steel-tripod form of decking support carries the weight of the automobile through the hub of the rear wheel and a spindle-bolt attachment.

HALF-DECKING

When only one end of an automobile is raised as has been described, the method is termed "half-decking." Usually, the front end is raised for this purpose, as the maximum clearance underneath the vehicle is gained in this manner, although the rear end can be raised if desirable. The decking equipment is similar to that used on the rear axle of an automobile when it is full-decked, or double-decked. Fig. 5 shows the method and the density of loading of automobiles on railroad flat-cars. In this instance, the rear end of the forward vehicle is half-decked and its front wheels are held by blocks accurately fitted to the tires and securely fastened to the flat-car floor.

When loaded directly on a freight-car floor, automobiles are fastened down by metal straps run over their axles if the machines have disc wheels and, if equipped with wheels of the artillery type, by a rope run through and around the wheel-spokes. Wheels are chocked fore-

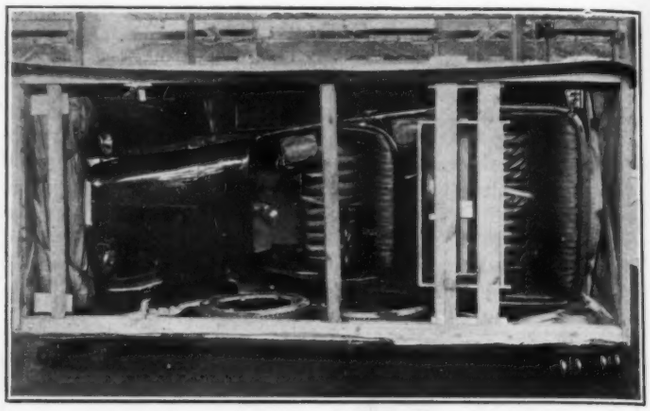

FIG. 8—A PHAETON "SIDE-LOADED" IN A CRATE FOR RAIL SHIPMENT
Two Such Crates Can Be Placed Side-By-Side on a Freight-Car Floor

and-aft with grooved blocks that fit the contour of the tire and keep the wheel aligned properly.

Fig. 6 illustrates the blocking used for automobiles that are equipped with balloon tires. For shipment, balloon tires are inflated to a pressure of say 55 lb. per sq. in. Dealers are instructed to deflate the tires upon arrival of the shipment. Springiness of the vehicle during shipment is thus minimized. The chock-blocks are fitted to these tires very accurately and are aligned carefully to prevent chafing and damage to the side-walls of the tire; they must not extend over the side-walls, as these must be free from contact with anything.

"SIDE" AND COMBINATION LOADING

So-called "side-loading" of an automobile for rail shipment, as shown in Fig. 7, is designed to economize space and yet will hold the vehicle rigidly in place. The automobile can be loaded and unloaded through the side door of a freight-car. Fig. 8 illustrates a phaeton side-loaded for rail shipment. Two such crates can be placed side-by-side on a freight-car floor. As shown in Fig. 9, this

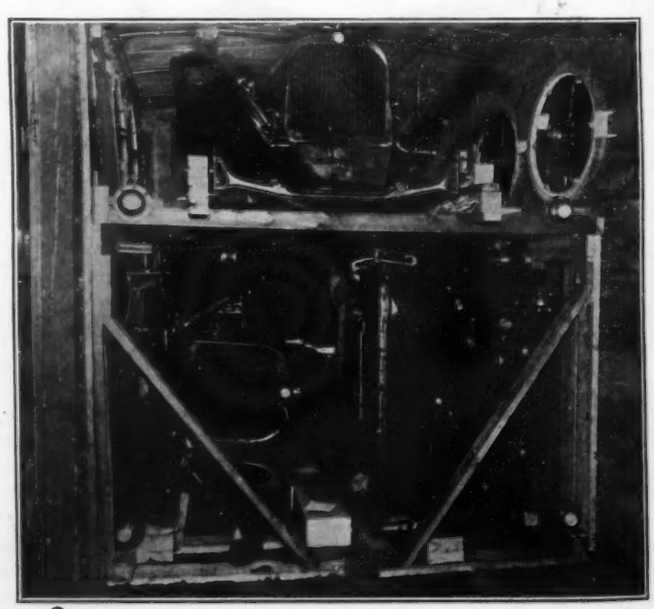

FIG. 9—COMBINED "SIDE" AND DOUBLE-DECK LOADING
Minimum Shipping-Space Is Illustrated Here by the Placement of Three Automobiles in One End of an Automobile Box-Car. All Wheels Are Removed and Attached Securely to the Sides of the Freight-Car, the Vehicles Being Supported at the Ends of Their Axles

method can be combined with that of double-decking. In this instance, three automobiles are placed in one end of an automobile box-car. All wheels are removed and attached securely to the sides of the freight-car, the vehicles being supported at the ends of their axles.

Inspection Methods

After automobiles have been loaded, four distinct inspections are made: (*a*) by a representative of the traffic inspector, to test all blocking and bracing; (*c*) bers and the numbers of all detached parts; (*b*) by a traffic inspector, to test all blocking and bracing; (*c*) by a sales-department inspector, to determine the condition of the vehicles at the time they are shipped, to locate cars or car parts that will not pass inspection and issue change orders and to ascertain if any parts are lacking and order that they be supplied; and (*d*) by a sales-department inspector, who investigates and records whether recommendations made by previous inspectors have been executed.

Following the four inspections, the freight-car door is closed and sealed. It should be noted that the final inspections occur *within the freight-car*, after the loading is complete. The inspection records are then checked against the assignment cards, the bills of lading are made out and are receipted by a representative of the railroad, and the freight-cars are carded properly and then sent out.

Shipment Overseas

Some automobiles designed for foreign service have right-hand and others have left-hand drives. These are boxed separately, but chassis are shipped two to each box. The preparation for foreign shipments is as follows:

All movable parts are fastened securely; the batteries are made "bone-dry"; gasoline, oil and water are drained out; any part subject to rust is greased; the tires are deflated; and the vehicle frame is held rigidly so that no movement can occur within the box. Waterproofed paper is used for lining. A good grade of dressed and matched lumber is used in making the box; it is put together with cement-coated nails, clinched wherever possible. Ample clearance is allowed between the vehicle and the box that contains it, and the box is made strong enough to withstand the other heavy loads imposed on it when it is stowed away on shipboard. Box corners are reinforced adequately and skids on the bottom of the box are provided to afford protection and facilitate handling at a port. All units are locked on against washers, to prevent the box parts from pulling loose due to lumber shrinkage during transit. The box is stencilled to show gross, tare and net weights, size and shipping directions.

Considering the great weight involved, the handling and rehandling to which these boxed shipments are subject, the various means employed for moving them and the many different forms of conveyance used, especially when they are shipped to inaccessible localities, it is remarkable what splendid results have been attained in shipping automobiles into foreign territory by this method.

It is interesting to note that our shipments of automobiles for a period of 1 year consume more than 24,000,000 board ft. of lumber and 1,250,000 lb. of nails. If the paper we use were unrolled and placed end-on-end, it would reach from Detroit to Boston.

Loss and Damage

Compared with the freight cost of wheat shipment, it is said that, in this Country, freight on shipments by the automotive industry costs 50 per cent of this total. If this be true, the 1923 statistics of 95 per cent of the American and 50 per cent of the Canadian railroads, aggregating 216 lines, show a total of 4.1 per cent only for loss or damage chargeable to automotive shipments, from all causes whatever. This proves the worth of the ways and means used for shipment.

NEW YORK CITY TRAFFIC CONDITIONS

WHY we should have surface cars running upon our streets, when a subway line and the automobile bus are paralleling the whole or a considerable portion of the same route, is a mystery to me. The policy I have repeatedly advocated is the scrapping of surface car-lines and the removal of their rails with the substitution in their place of the flexible bus. No valid argument for retaining surface car-lines can be presented. They are no longer a help in the City of New York; they are a hindrance. Their replacement by buses throughout the Country is becoming commoner every day.

The New York Railways Co. announced recently that more than 3,000,000 fewer passengers were carried on its lines during the 9-month period ended March 31, 1924, than during the previous similar period. The traffic that the surface-car systems lose is usually gone forever. The stage-coach, the horse-drawn car and the surface car belong to the day when old New York was young. The comfortable, swiftly moving motorbus is now the demand.

In the hope of producing good results from the traffic standpoint, we have not only advocated the removal from our streets of elevated and surface car-lines, but we have also given careful consideration to such plans as vehicular tunnels, the widening of existing roadways, the laying out of spacious streets and boulevards in unmapped sections of the city, the introduction of arcaded streets, the removal of subway-station entrances from the center of roadways where many of them were placed when some of our subway lines were first opened, the requiring of new buildings to be set back to such lines as would permit of the ultimate widening of the street and the cutting through of express streets in congested sections, which in some instances would cost about $25,000,000 a mile and would probably have horrified the street commissioners of 1811, who at that time referred to the price of land as "so uncommonly great." New York City must stretch its limbs through Westchester County possibly as far as Poughkeepsie, from the Hudson River to Long Island Sound, reaching to the State line of Connecticut and through the Borough of Queens running far into Long Island. These are to be pictured as areas in which New York City may have to find room for its increasing population during the next generation. New York City's expansion of the past has been rapid and well-nigh phenomenal. To provide for such future inevitable expansion now, based on the experience of the past, would be the part of wisdom.—Mayor Hylan, of New York City before Conference on Regional Plan.

When Does a Motor Truck Become Obsolete?

By F. W. Davis[1]

Metropolitan Section Paper

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

Is obsolescence merely a question of age, or does the maintenance a motor truck receives play an important part in determining its life span? The author undertakes to answer this question by citing numerous references to articles on this subject and by discussing the various factors that make for obsolescence, inadaptability and uselessness.

The original purchase price is settled by the personal judgment of the buyer but, as soon as operation begins, maintenance must begin also, for an idle truck earns no money. As the range of operation may extend from complete idleness to continuous 24-hr. service, so maintenance may vary from efficient supervision to ill-advised mechanical attention.

As the development of motor trucks has been too short to permit the writing of their life history, recourse is had to the record of locomotive development, which is considered to be relevant because of the similarity of the paths of progress of locomotives and motor trucks. A. M. Wellington's figures on the life of locomotive parts are shown to be based on age, but are found not to apply accurately to motor trucks because of the varying conditions under which motor trucks operate. In the last 15 years many changes have taken place in the design, and many improvements have been made in the materials, the methods of construction, the interchangeability of parts and the accessories, of motor trucks. The capacity and operating economy have been increased, and the use of auxiliary equipment for loading and unloading the motor trucks and of power devices for utilizing the power of the engine has progressed. But improvement has been confined chiefly to the details.

Many motor trucks of the vintage of 1910 are still in service and many old trucks show an ability to perform their work equal to that of the new ones. Locomotives are sent to the shop for general repairs after they have covered a certain mileage but the cost of the repairs varies with (*a*) the time and age, (*b*) the number of starts and stops, (*c*) the terminal service, (*d*) the curvature and grades and (*e*) the distance covered.

The fundamental reasons that the subject of depreciation is not better understood are the lack of uniform cost-keeping and the youth of the industry. Depreciation is produced through the tendency to become obsolete, inadequate or useless. A distinction must be made between the natural and the operating life; the former depends upon the three factors given above, whereas the operating life depends on the amount of use the truck receives before it becomes worn out. The most readily adaptable and most widely used method of applying depreciation is the so-called straight-line system. This system does not correspond to either the natural or the operating life but is an arbitrary figure. The rate of depreciation depends upon the first cost, the interest rate compounded, the life of the equipment and the scrap value. Many trucks continue to operate beyond the period of depreciation; when they do, the interest on the sinking fund will help to defray the repair and overhauling charges. When a truck becomes old, the securing of spare parts becomes very important and failure to obtain them will greatly increase the expense of maintenance.

Sometimes, because of poor design or lack of adaptability to the work, a truck becomes inadequate to perform the service required. Expensive changes are then necessary to increase the adaptability by improving the loading and unloading facilities, the ability to meet road conditions, the operating convenience and the protection of the driver.

Uselessness seldom applies to a motor truck that becomes useless only when the service for which it was intended is no longer required. In some lines the advertising value of vehicles is important; it pays to cater to the wishes of the public in the matter of style, appearance, color schemes and the like. Interchangeability of units will assist in prolonging the operation of motor trucks, and the standardization of mountings, accessories and control location are the answer to the situation produced by orphan trucks and the lack of spare parts. The time to determine the fitness of a motor truck for continuing service is immediately before an expensive overhauling. Each case must be judged on its merits. As the future promises no radical changes in design or in operating economy, the items of supervision and maintenance will continue to be the controlling factors in determining the time at which motor trucks should be retired.

Motor trucks cost money to purchase, to operate and to maintain. The question of the original purchase price is settled by each individual manufacturer and the truck user can make his selection over a wide range. After the vehicle has been purchased, the owner is immediately faced with the problem of operating it, because an idle truck earns no money. The range of operation extends from total idleness to the other limit of continuous uninterrupted day-and-night service. Obviously, the problem of operation calls for much skill and knowledge of hauling conditions. No sooner is the vehicle in operation than the other item, maintenance, must be faced. This important phase of the operation of motor trucks also varies from a very small figure, in the case of highly efficient supervision and mechanical attention, to four or five times this figure, in the case of inadequate supervision and ill-advised mechanical attention.

Widespread interest in the subject of truck operation and maintenance exists and the Metropolitan Section of the Society, during 1924, received two very able papers on certain phases of these subjects. On Feb. 14, R. E. Plimpton presented a paper[2] entitled An Analysis of Costs for Ten Years of Fleet Operation, and on April 17 J. F. Winchester presented a paper[3] entitled Observations of a Superintendent of Motor-Truck Fleet-Operation. Preceding these two papers, F. J. Scarr published

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[2] See The Journal, May, 1924, p. 539.

[3] See The Journal, May, 1924, p. 496.

an article[4] entitled Retire Your Trucks at the Proper Time. This article was followed in subsequent issues by letters from a number of outstanding figures in the motor-transport world. These letters show a certain amount of agreement, but on the whole present a number of diverging viewpoints, and no real conclusions are reached.

The panacea for this situation either has not been suggested or lies in a reiteration and a boiling-down of some of the viewpoints presented. A mass of evidence is at hand. I propose to utilize this information in attempting to clarify the subject further.

Walter E. Parker, president of the Commerce Motor Truck Co., states the manufacturers' viewpoint as follows:

> There is only one economical method of handling the truck business and that is to have owners use the motor trucks until their usefulness is exhausted and then to scrap them.

This statement of the situation fairly answers the question, When does a truck become obsolete? The expression, "until their usefulness is exhausted," needs considerable study, however, before we can arrive at the proper meaning and evaluation of the words "usefulness" and "exhausted."

Modern-Truck Operation

In digressing to get a clear picture of the present status of motor trucks, let us consider the cycle of development. Four periods immediately come to mind. The year 1900 witnessed the first experimental attempts to transport merchandise by motor vehicle; in 1910 came the first serious attempts at quantity production of motor trucks; by 1915 there was world-wide recognition of the motor truck as an instrument of dependability and of enormous capacity for work. In this period also great numbers of trucks were used under efficient supervision and maintenance in war activities. After the war, another period witnessed the utilizing of the lessons learned during wartime operation and serious efforts were made by manufacturers to meet the users' requirements.

Twenty-five years, then, is the total span between the practical inception of the motor truck and the present time, of which 15 years represents the practical development of the motor truck in the hands of the user as an instrument of transportation. The industry surely is very young and in the years to come our present knowledge and conclusions are bound to be altered in the light of experiences. Design has undergone detail changes through improvements of materials, improvements in production methods, interchangeability of parts and the standardization and the improvement of accessories. The capacity of trucks has undergone development in the way of increased engine-power, lower gear-reductions, greater ease of handling and better protection for the driver. Operating economy has increased, owing to the virtual reduction of first cost, by which the overhead expense has been reduced. This statement may require some explanation because of the fact that prices today are higher than those of previous periods. The purchasing power of the dollar, however, is less and an uptodate motor-truck includes equipment and accessories far in advance of those of the early models. The operating expense for fuel, lubrication and tires is lower on account of a more efficient utilization of fuel and lubricants and a great improvement in the quality of the tires. The up-keep expense has been materially reduced because of the items of interchangeability and standardization mentioned above and also the use of materials better suited to the purpose. The development of auxiliary equipment has progressed in the way of better-adapted bodies, improved loading and unloading facilities and devices for utilizing the power of the engine.

Improvement Mainly in the Details

After all this so-called progress, we might be led to expect a revolutionary change in the results obtained from the present-day motor-truck as compared with its early prototype. Such, however, is not the case. The development has all been in the improvement of details, with nothing particularly outstanding. In outward appearance motor trucks remain about the same. Motor trucks of the vintage of 1910 are doing their work today and show no signs of wearing out, in the popular understanding of the term. Furthermore, it is necessary only to cite the case of one of the large coal companies of Milwaukee, which purchased a large fleet of trucks after operating a few vehicles for several years. When the driver of one of the original vehicles was offered one of the new trucks, he pleaded to be allowed to remain on the 6-year-old vehicle, and subsequent results showed that this driver hauled a tonnage with the old truck that was equal to those of the new fleet.

Examples could be cited of old trucks performing alongside new ones. The answer, however, is only to be obtained by a thorough knowledge and understanding of the cost of operation. Many operators today fail to realize the absolute necessity for keeping accurate cost-records. The following quotation is from a communication[5] in *Motor Transport:*

> The average motor-vehicle operator contends that statistics do not make a vehicle profitable. Of course they do not; neither does a clinical thermometer cure a disease. But the statistics show wherein the motor vehicle costs are too high, even as the thermometer shows when a patient has fever. Knowledge is power; and, by proper analysis of the cases in hand, both the motor-vehicle trouble on the one hand and the sick patient on the other can be treated intelligently and effectively.

E. E. LaSchum[6] in the same issue of *Motor Transport* makes the following statement:

> This individual cost-record is desirable for many reasons. It might actually show up the "white elephant," but it may also show what makes it so and what can be done to better its performance.

It does not follow that, because a user continues to operate motor trucks of the vintage of 1910, it is economical to do so; and right here is the crux of the whole situation. The fundamental reason that this subject is misunderstood and the occasion of controversy wherever it is introduced is undoubtedly chargeable to (*a*) Lack of uniform cost-keeping and (*b*) The youth of the industry. No way of speeding-up the passage of time is apparent; consequently, if we are to obtain advance information on this subject, we must do so by some indirect method. Can we not tap a source of information that will guide us through our childhood and point the way out of our squabbles? Railroad operation obviously furnishes a mass of accurate information that is well worth delving into, to see whether we can obtain guidance from it. Aside from operating on rails and pulling, instead of carrying, the pay-load the problems of rail-

[4] See *Motor Transport*, Nov. 1, 1923, p. 215.
[5] See *Motor Transport*, Dec. 15, 1923, p. 343.
[6] See *Motor Transport*, Dec. 15, 1923, p. 342.

road operation parallel very closely those of the motor truck.

Comparison with Railroad Operation

Many books deal with the operation of railroads and contain uniform cost-figures extending over a considerable period of time. That great author, A. M. Wellington, in 1887, produced a volume entitled Railway Location, which is a classic in railroad literature and a veritable fountain of information even at the present time. It is not the province of this paper to discuss locomotive maintenance or other problems far outside our present scope. It is instructive, however, to consult the tables giving the length of life of locomotives and their parts. The life of an American locomotive is from 22 to 24 years; of tenders, 10 years; of boilers, 15 years; and of fireboxes, 6 years; or, stated in approximate mileages, as given in Table 1.

TABLE 1—LENGTH OF LIFE OF LOCOMOTIVE PARTS IN TERMS OF MILEAGE

Locomotives, as a Whole	700,000
Tenders	800,000
Boilers	450,000
Fireboxes	180,000
Axles	300,000
Bearings	50,000
Tires	200,000
Truck Wheels	34,000
Tender Wheels	50,000
Valves	75,000

Locomotives on the Pennsylvania Lines go into the shop for general repairs once every 18 or 20 months, or about every 50,000 or 60,000 miles. The cost of maintenance per locomotive-mile, as given by Wellington, averages from 5 to 6 cents. This is considerably lower than the cost of maintenance per mile of the average 5-ton truck. It is customary, in making a comparison of the repairs and the maintenance expense of truck fleets, to use the cost per mile. This is a convenient one to use. Unless the particular conditions of operation are taken into account, however, the comparison is of very little value. The conditions of motor-truck operation can vary considerably more than those of railroad operation. On the subject of repair expense per mile, Wellington states:

> It is customary to consider the repairs of engines and cars to be proportioned to the distance covered. In reality they arise from several distinct causes, of which the regular running-wear when in motion is only one. These causes are
>
> (1) Time and age; varying with time
> (2) Stopping and starting; varying with the number of stops
> (3) Terminal service, getting up steam and the like; varying with the number of trips
> (4) Curvature and grades; character of alignment
> (5) Varying with distance
>
> Considering the immaturity of the motor-truck industry, and bearing in mind that we shall ultimately have a knowledge similar to that relating to railroading, it is not untimely at this stage of the development of motor trucks to say, "We are talking about something that we do not known much about."

Does Cost Increase with Age?

The passing of time brings about a change in the comparative values of things. If the comparative values decrease, we have depreciation; if they increase, we have appreciation. Any given article depreciates through its tendency to become (*a*) obsolete, (*b*) inadequate or (*c*) useless. In an admirable book entitled Financial Engineering, O. B. Goldman distinguishes between (*a*) natural life and (*b*) operating life. Natural life, in turn, depends on the three factors of depreciation mentioned above. Operating life depends on the amount of use the truck has received before it becomes worn out. The shorter of the two determines the true life of the unit. Some slow-speed steam-engines have continued in use after 40 years of operation. These units obviously have outlived their natural life, as explained above, although they still possess operating life as evidenced by their continued use.

Depreciation reserve is a means of assuring continuity of service. It is necessary to lay aside a certain sum of money during the life of a motor truck or other equipment to insure against interruption of service when the motor truck or other equipment is retired. It is desirable that this reserve should be handled without too much complication. The courts likewise endorse a simple method of handling this item; tax requirements also have a bearing. The most readily adaptable and widely used system is the so-called straight-line method of depreciation. A sum of money put aside each year will continue to draw interest; consequently, to this sum must be added the usual interest-rate compounded. The depreciation rate therefor depends on (*a*) the first cost, (*b*) the interest rate, compounded, (*c*) the life of the equipment and (*d*) the scrap value.

Depreciation an Arbitrary Figure

In this case, the life of the equipment does not correspond either to the natural or to the operating life, as explained above. It is merely an arbitrary figure, which, if standardized in all truck operations, would be of great benefit in future analysis. The figure, 5 years, for the depreciation life appears to be a very workable one. If this is chosen, then, according to the sinking-fund method, it will be necessary to put aside slightly less than 20 per cent of the first cost each year, depending on the interest value of the money.

Trucks often continue to operate beyond the 5-year period, a fact that causes some operators to criticize that basis of depreciation. When the equipment operates for 5 years, the depreciation arrives at zero; any further operation will bear no depreciation and the interest on the sinking fund will help to defray the repair and overhauling charges. J. F. Winchester states this as follows:

> In addition to this, an operator, under average conditions, has charged off all parts on a given vehicle for depreciation; so, today, this item alone, set aside as a reserve fund, will more than take care of the running repairs and the periodical overhaul.

In the maintenance of motor trucks, the securing of spare parts is of the utmost importance, for without the ready supply of spare parts a great loss of time and other incidental expenses out of all proportion to the value of the parts in question are incurred. This element, though most provoking, is but a little more costly than the practice followed in some fleets, in which the seasonal demands are great, of carrying out extensive overhauling programs once a year with the idea of getting through the heavy season without interruption. This is correct in theory, but when it involves such items as regrinding cylinders, reseating valves, replacing costly ball-bearings and regrinding crankshafts, the practice is expensive and uneconomical, to say the least.

Another item of maintenance, involving the inter-

changeability of parts through changes in design, is also mentioned by Mr. Winchester and is a point well taken. It is certainly the duty of the manufacturer to supply the user with uptodate information regarding the changes that have been made in his product, to facilitate servicing problems. The Society can well devote some time to formulating a method of procedure on this subject.

When a truck continues in service over a period of years, the difficulty of securing repair parts becomes more and more acute. Certain so-called non-wearing parts, such as axles, frames, cross-members and engine bases, begin to fail. When truck construction becomes more standardized we shall be able to outline a table showing the approximate life of the various units that will be comparable to the locomotive figures quoted from Wellington. All this evidence tends to indicate that as a truck grows older, the maintenance cost increases. No reason exists that this cost should mount up until the non-wearing parts begin to fail and the replacement parts become unavailable. Mr. LaSchum makes the point that from 1916 to 1921 the cost gradually increased and that since 1921 the cost has decreased. He attributes the first period to the general rise in labor, material, and the like and the second period to correct methods of maintenance, together with a reduction in the cost of labor and material.

Reluctance to Discard Old Trucks

Some users seem strangely reluctant to retire old motor-trucks. One company in particular that operates a fleet of oil trucks had an orphan truck on its books that showed a few days of operation each month. The superintendent of motor equipment, wishing to maintain the vehicles on the road, managed to secure from 2 to 3 days' service each month from the orphan truck. The services of a tow-line, however, were always required to bring the vehicle back to the garage. A large retail-house in the West was reluctant to discard some orphan trucks. Among other conditions, the engines in these vehicles required replacing. With no spare parts available, the fitting of new engines of another make involved very expensive alteration; the vehicles had covered their economic life. When vehicles of this description are continued on the road their productiveness suffers. They are continually subject to forced repairs, as opposed to natural repairs, which results in a very much increased cost of operation.

By "orphan" truck is meant a vehicle whose manufacturer is out of business, or one for which the parts are not obtainable.

Sometimes motor-truck equipment becomes inadequate to perform the service required. This may be caused by poor original design or by lack of adaptability to the work. By adaptability is meant (*a*) loading and unloading facilities, (*b*) ability to meet road conditions and (*c*) operating convenience and the protection of the driver.

Extensive changes are often carried through to improve the adaptability of the vehicle. A national distributing organization found it desirable to change over its tractor-trailer units to straight motor-trucks, an operation that involved the complete rebuilding of the vehicles on a standard-length frame. This change was made advisable on account of the inability to check the contents of a trailer body that had been loaded in the absence of the driver. Another large transfer-company in the Middle West found it desirable to change its standard motor-trucks to tractor-trailer units to allow economies in loading and unloading and in the transporting of larger loads.

Obsolescence a Relative Term

In the matter of obsolescence, the early makes of motor truck on the road today that have received proper service and maintenance and are not orphan trucks in any sense cannot be termed obsolete. They cannot compare with the modern truck with regard to ability to perform, nor can they show equal gasoline and fuel-economy. They are still able, however, to perform the work for which they are fitted and are not obsolete. This delegating of early trucks to services for which they are fitted is an important one; otherwise, they must be considered obsolete, for they do not compare in performance ability with modern trucks. But the matter of obsolescence is so far outshadowed by other factors that have been discussed in this paper that it becomes of relatively small importance. It has very little, if anything, to do with the ultimate or the economic life of motor trucks. Furthermore, the age of motor trucks in itself has very little to do with their life. A motor truck can be considered to be at the end of its economic life only when it fails to render proper service.

The element of uselessness very seldom applies to motor trucks. A motor truck becomes useless when the service for which it was intended is no longer required. In some cases, contractors use motor trucks to accomplish a certain purpose and figure 100 per cent depreciation during the period of the work. The motor trucks, in most cases, complete the work and are then ready for other work or for resale at a very good figure. The item of uselessness hardly applies. It has more to do with temporary structures, and the like, that have no use after the project has been completed.

As the aging of motor trucks continues, bringing about the failure of non-wearing parts, an increased difficulty in obtaining spare parts, and a decrease in productiveness because of forced repairs, the cost of operation increases and the productiveness of the vehicle decreases. This fluctuation should not become evident during the early life of the vehicle but will mount steadily and rapidly as the vehicle approaches the end of its economic life.

The Proper Time to Retire Trucks

Mr. Scarr, in his article[1], gives a formula for determining the proper time to replace an old truck with a new one. I am unable to check this formula from either a theoretical or a practical standpoint. Mr. Scarr takes a bold step in endeavoring to reduce the problem to a simple formula. Without wishing to take issue with Mr. Scarr, it appears desirable, in view of the widespread discussion invoked by the article, to consider the meaning of the formula. In the case of the old truck, Mr. Scarr arrives at the total cost per unit up to the time of the next overhaul, and calls it E. The new truck is evaluated to L, which equals the cost per unit of the new vehicle during the same period of time, as that during which the new vehicle absorbs the difference between the book value and turn-in allowance of the old unit. If the value of L is lower than E, the choice will be in favor of the new truck; but if E is lower than L, the decision favors the continuing of the old vehicle. In many cases the book value is zero; when this is so, the balance will always be in favor of the new unit. In other words, unless the book value is enough greater than the trade-in value to counterbalance the difference in total maintenance for

[1] See *Motor Transport*, Nov. 1, 1923, p. 215.

the period in question, assuming an equal output of work, the choice will favor the new vehicle. But, on Mr. Scarr's assumption of the reduced productiveness of an old vehicle as compared with a new one, and also bearing in mind the lost time of the old vehicle while in the repair shop, the conclusion is evident that the second-hand problem is a menace. I am not in accord with this viewpoint. Age alone has very little to do with the economic value of the truck, yet, in Mr. Scarr's formula, age, controlling the book value, is the predominating factor.

In casting about for a theoretical statement of this problem capable of treatment by formula, Goldman states the case very effectively and accurately when he says:

> Whenever the cost of the maintenance of an old unit is greater than the total cost, that is, the fixed charges and the operating cost, of a new unit, it is evident that it will pay to discard the old unit. In such a case it is worn out.

Advertising Value of Appearance

In addition to the factors bearing on the economic life of a motor truck, certain others often may control. In the transportation of passengers and in certain retail trades, the advertising value of vehicles is of great importance. It pays, therefore, to cater to the wishes of the public in the matter of style, appearance, color schemes and the like. Evidently, no measuring stick will apply to this factor.

Accidental injury sometimes makes it desirable to replace a motor truck, and some day we may aspire to having truck frames, axles and other non-wearing parts subject to the form of life described by Wellington, in speaking of the life of locomotive frames, as "a question of accident." This is a vision of the future, inasmuch as motor-truck parts do not enjoy this happy span of life.

Intelligent operation is slowly overcoming the evils of overspeeding and overloading. These factors probably have to do, more than anything else, with the so-called failure of non-wearing parts. They also probably account in great measure for the wide variation in maintenance costs, that amount in some cases to three or four times as much as those of similar trucks in corresponding lines of service. The failure of a non-wearing part always means a costly replacement, for it usually involves the dismantling of a considerable part of the vehicle, the cutting out of rivets and similar difficulties, for truck designers usually overlook the necessity for making parts readily detachable.

The interchangeability of units, such as the engine, the transmission and the axles, will go a long way toward facilitating the continued operation of motor trucks and will nullify the inability to obtain spare parts. Economic laws take their toll among motor-truck manufacturers and leave quantities of orphan trucks; and manufacturers often make a series of changes that vastly complicate the servicing problem. It might be inferred that the manufacturers could speed-up the retirement of old trucks by discontinuing the supply of spare parts. The standardizing of mountings, together with accessories and the control location, is the answer to the situation produced by orphan trucks and the lack of spare parts.

Effect of Lost Time

Lost time or time out of operation on account of involuntary causes has a very definite bearing on economic life. Goldman states this problem very aptly: "An equipment must earn its costs and profits while in operation, for certainly it cannot do so while idle." Some motor-truck users find it desirable to utilize as reserve vehicles trucks that have passed their economic life for continuous service. This is a doubtful economy, for the reserve vehicle usually is undependable enough to make it a liability rather than an asset. Goldman states the case very plainly: "Like most things, a reserve unit is desirable in inverse proportion to its cost. When the cost rises above the probable gain, it is no longer good judgment to provide it [the reserve unit]."

Mr. Scarr is perfectly right when he says that the time to determine the fitness of a motor truck for continuous service is immediately before an extensive overhauling. Each case must be judged on its merits and after full consideration of the factors outlined. This is the only possible way to arrive at the answer to the problem, and no reason exists for expecting a change in the future. Most assuredly, it is impossible to predict the proper time to retire motor trucks. The future promises steady improvement in all the factors that tend toward better economy of operation. Neither the fuel situation, however, nor present-day inventions promise any radical changes in design or in operating economy, and the items of supervision and maintenance will undoubtedly continue to be the controlling ones in determining the proper time for retiring motor trucks.

OUR IMPORT TRADE

OUR industrial development has now become such that our import trade no longer consists principally of the finding and bringing into the United States of distinctive and exceptional articles likely to appeal to the taste of special groups or classes of American consumers; we have today great industries whose very life depends upon abundant supplies of raw materials that this Country does not produce. For purposes of illustration it is enough to mention in this connection the great tin-plate industry; the huge rubber and tire industries; the extensive industries using jute and burlap as a raw material; the woolen industry, more than half of whose raw material must be imported; the leather industry, whose position is similar to that of the woolen industry; the silk industry; the industries using sisal and hemp; and so on with a long list. Nor must it be forgotten that the comfort and satisfaction of living for the American people as a whole would be greatly diminished if it were deprived of the imported coffee and tea, bananas and other tropical fruits and foodstuffs and numerous other articles of diet to which it has become habituated. No long reflection upon these facts is required to make it clear that an adequately developed import trade is at the present time scarcely less a necessity to the United States than an adequately developed export trade. In truth, the two are complementary the one to the other, forming inseparable parts of a single problem.—A. R. Marsh in *Economic World.*

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Changing the Horse-and-Buggy Road To Fit the Automobile

By S. D. WALDON[1]

DETROIT SECTION PAPER *Illustrated with* DRAWINGS AND PHOTOGRAPHS

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ABSTRACT

PUBLIC thoroughfares have invariably been laid out to meet the requirements of age-old horse-and-buggy equipment and little thought has been given to the needs of the future. Until the middle of the last century, man was dependent for transportation upon his own strength or upon that of the animals that he could domesticate. Caesar could have traveled from Rome to Paris as quickly as could Napoleon 17 centuries later. Now, the humblest American farmer could make the round-trip with his whole family in less time than either emperor could travel one way. Within the last century have been developed in rapid succession the railroad train, the steamship, the electric trolley-car, the automobile, the motor truck, the tractor and the airplane.

The most permanent thing we have is land; the very slowness and regularity with which buildings are replaced tend to make a route and the width in which it is established almost as permanent as the land of which it is a part. In many European cities buildings are clustered so closely together that it is difficult for a wheeled vehicle to pass through the streets. The natural tendency of persons residing along a highway is to encroach upon it if an opportunity presents itself, so that the trend is toward making it the minimum possible width, and little regard is had for the future. America's early settlers changed many of the old European conditions and set up new standards on a broader scale.

In Detroit, three instances of broad vision and courage in route-planning are outstanding. After the fire, in 1806, the Governor and the Judges, the governing body at that time, having obtained authority from the Congress, laid out a new city based upon standards of right-of-way width of 200 ft. for major thoroughfares, 120 ft. for secondary radial arteries and 60 ft. for residential streets. But subsequent generations have failed to conform to the plan, except in a few instances.

In 1824, Governor Cass obtained authority to lay out five great radial thoroughfares as military roads, 100 ft. in width, and, between 1877 and 1883, a group of citizens obtained and dedicated to public use 11.6 miles of right-of-way, varying in width from 150 to 200 ft. and extending from a point opposite Belle Isle around the city to its juncture with the Detroit River on the west. With the exception of these three examples of planning, Detroit has grown along its radial arteries in a more or less haphazard manner.

In the automobile, a mechanism for replacing the horse, man has found a substitute for the railroad train, the steamship and the trolley-car, which are essentially for mass transportation. With it the owner has increased his ability to earn and that of his family to enjoy life. The 53,000 automobiles that were added last year to the registration of Wayne County have a carrying-capacity of 265,000. If all the cars were to swing into Woodward Avenue at Grand Circus Park at the maximum rush-hour rate per lane of traffic, it would require seven and one-half 12-hr. days before the last vehicle would reach Jefferson Avenue. Parked on both sides of the street, they would require a street 86 miles long.

Because the individual's range of action has been increased from 10 to 20 times, his capacity for purchase has been correspondingly enhanced. Land formerly of no value because of its inaccessibility is now more accessible and of more value.

Having developed the automobile, Detroit is now making an effort to provide the proper facilities for its use. Fortunately, because of a hobby of E. N. Hines, chairman of the Board of County Road Commissioners, Wayne County has a greater mileage of concrete roads than any other county in the Country or in the world. Of the 400 miles of improved roads in Wayne County 365 are of concrete. Through the assistance of Governor Groesbeck in reestablishing the fundamental principle that roads should be built by routes and not in disjointed sections, much progress has been made in providing a solution of Detroit's problem. A description is given of the master plan to which Detroit is endeavoring to make its street improvements conform, and the suggestion is offered that additional rights-of-way should be acquired at once, before other improvements are carried out that will make condemnation expensive or impossible. A plan is outlined for a superhighway that will meet modern requirements and make rapid operation safe.

THE subject that has been assigned to me this evening, Changing the Horse-and-Buggy Road to Fit the Automobile, is both intensely interesting and vitally important. For the purposes of this discussion I shall consider that the term "Horse-and-Buggy Road" is not limited in scope but comprehends all public thoroughfares, whether they be city streets, county roads or State highways.

The problem that the subject suggests is probably more insistent in its demand for solution than any other that confronts the people at this time. It is inevitable that it will become far more pressing than it is now, particularly in and near the large centers of population, before any substantial relief can be provided. We have changed so rapidly and so universally from the horse and buggy to the automobile that we find it impossible to change with equal rapidity from the age-old horse-and-buggy facilities to the new requirements of the motor vehicle.

Let us briefly review what has led to our present situation, what is being done to meet the change that is taking place, and what further planning and development are necessary to provide properly for the future. Looking backward, we find that from the time of Caesar up to and through Napoleon's regime, man made practically no advance in the standards that governed his in-

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dividual transportation. In all that period of time he was dependent for rapid transportation on land upon his own physical strength or upon that of the animals that he could domesticate. On water, he was dependent upon himself or upon the vagaries of the wind to propel his craft. And then, in the relatively short space of a century of time, man developed in rapid succession the railroad train, the steamship, the electric trolley-car, the automobile, the motor truck, the tractor and the airplane. This evening we are concerned mainly with the problem presented by the automobile and with the changes in individual transportation on land that it has brought about.

The Horse the Standard of Transportation

For 1800 years the horse was the last word in rapid transit, and all city and trunk road-planning was made to fit it as a standard. Then, every former measure of time and distance for individual transportation was wiped out by the development of the automobile. Caesar could travel to Paris upon the trunk-line roads that he laid across the map of Europe just as fast as Napoleon could make the distance to Rome 17 centuries later. Today, the humblest American farmer or workingman can put his whole family aboard his automobile and make the equivalent of the Paris-to-Rome round-trip in less time than either emperor could have traveled one way the distance between the two cities.

The majority of every generation is prone to regard its own time as a finality, the sum total of all time. Only in rare instances do we find evidence, through far-visioned plans, of man's appreciation of, and obligations toward, the time that is to come. Caesar built roads to facilitate rapid transportation to and from Rome as a means of ensuring the fulfilment of his own ambitions. But, though the surfaces of the roads that he laid have long since passed away, the routes still remain. Bordered by modern buildings, surfaced by modern methods and traveled by modern vehicles, they now serve the people of our time.

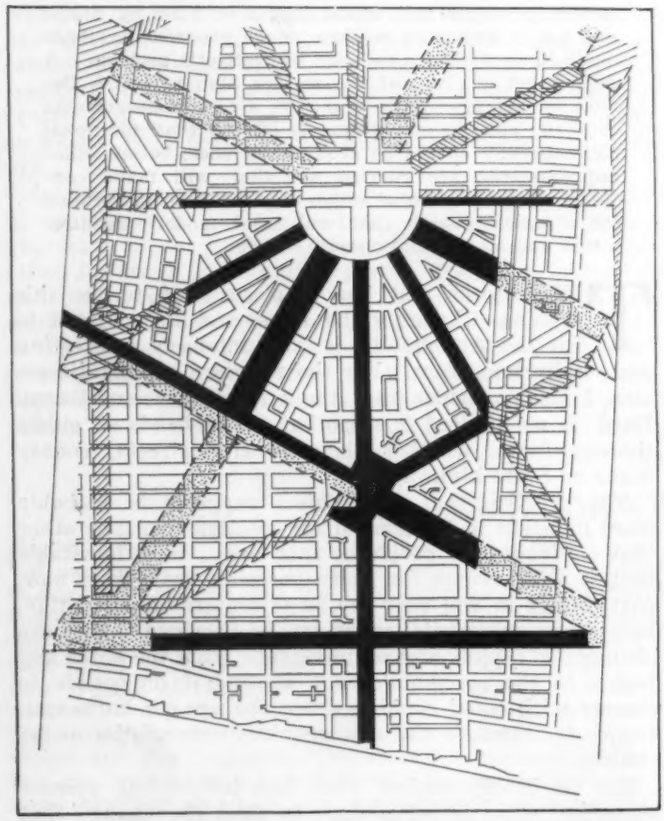

Fig. 1—Remnant of the Governor and the Judges' Plan that Remains in the City of Detroit

This Plan, Which Was Adopted in 1806 after Fire Had Destroyed the Fur-Trading Post That Was the Forerunner of the Present City, Was Based Upon Three Standard Widths of Right-of-Way. These Were (*a*) 200 Ft., for Major Thoroughfares Running in All Four Directions; (*b*) 120 Ft., for Secondary Radial-Arteries; and (*c*) 60 Ft., for Residential Streets

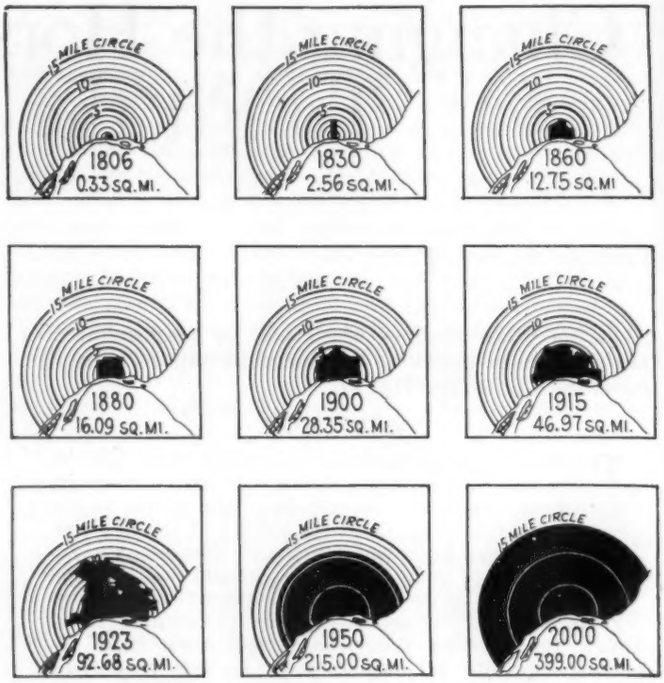

Fig. 2—Expansion in the Area of the City of Detroit Since 1806

These Charts Indicate how the City Has Grown from a Log Village on the Edge of a Forest Wilderness Covering only 0.33 Sq. Miles, to a City Extending in 1923 Out to the 5-Mile Circle and in Many Cases Beyond, and Covering 92.68 Sq. Miles. The Projected Areas of 1950 and 2000 Are Also Shown. The 5-Mile Circle Is Considered as the Limit of Satisfactory Surface Street-Car Service and the 10-Mile Circle as the Limit of Satisfactory Two-Track Local Rapid-Transit Service. In Both Instances 45 Min. Is Considered as a Reasonable Time-Limit from Home to Work, a ¼-Mile Walk Being Included in the First Case and a ½-Mile Walk in the Latter

For 18 centuries, people in all lands have been thinking, planning and building rural roads and village and city streets, with one standard of transportation in mind. Small wonder then that we should find it difficult to change an order of things that has so many centuries of precedent behind it. The very slowness and irregularity with which buildings are replaced tend to make the route itself and the width in which it is established almost as permanent as the land of which it is a part. The most permanent thing we have is land, to which, during our short lives, we lay a temporary claim. It alone endures, but, following it closely in permanence, is the right-of-way width of road and street by which land is made accessible and useful.

In the older cities of Europe there are whole sections in which the buildings are clustered so closely together that they make it difficult, if not impossible, for a wheeled vehicle to pass through the narrow ways. Thousands of miles of what were formerly local roads have gradually been enveloped by villages and cities and been compelled to carry through-traffic, for which they were not designed, with consequent congestion, confusion and delay. The route capacity had served the previous generations. So, why change it? The natural instinct of

the property owner was then, as it is now, to hold all he had and to encroach upon the public highway, if an opportunity should present itself. Consequently, the general tendency has been toward the minimum roadway that would serve for the moment, with no thought of the future.

America is new, as time is measured, and its early settlers, fresh from the age-old conditions of Europe, in many cases made new and broader standards for man and horse transportation. The City of Washington, with its plan of radial and parallel streets of generous width, is a splendid example. Michigan can boast of three outstanding instances of vision and courage in route-planning and accomplishment.

Outstanding Instances of Route-Planning

The first occurred 118 years ago, just after the fire destroyed the City of Detroit, when the Governor and the Judges, the newly constituted authority over the territory, obtained from the Congress authority for the laying-out of a new city. Detroit was then a fur-trading post. Its population was 1400; and its area 1/3 sq. mile. Wayne, Oakland and Macomb counties were part of a wilderness of forest, lakes, hills and swamps. The area of the entire city was less than what is now a good subdivision. What the Governor and the Judges did was to make Michigan's first subdivision plat. This is shown in Fig. 1.

The plan adopted was based upon three standards of right-of-way width: (*a*) 200 ft. for major thoroughfares running north and south and east and west, (*b*) 120 ft. for secondary radial arteries and (*c*) 60 ft. for residential streets. The great difference between the Governor and the Judges' plan and the subdivisions of the present time is not so much that the former was the first plat made, as that the capacity of the streets it contained is so enormous. It was the intention to have all these widths observed in the planning of future additions to the city. But subsequent generations failed, except in the case of Jefferson Avenue, to conform to the plan. Washington Boulevard, Madison Avenue and Cadillac Square are parts of the 200-ft. main streets of the former time, while Bagley, lower Woodward, Broadway, Monroe and Jefferson avenues are examples of the 120-ft. secondary radial arteries.

The second accomplishment occurred in 1824, just a century ago, when Governor Cass, obtaining Congressional authority and appropriations, began the laying-out of Michigan's five great radial thoroughfares leading from Detroit to Perrysburg, Ohio; to Fort Dearborn, at Chicago; to the mouth of the Grand River; to Saginaw; and to Fort Gratiot. All these were established as military roads, 100 ft. in width, but they have been so encroached upon by succeeding generations that the State is obliged today to buy back the right-of-way that already rightfully belongs to it.

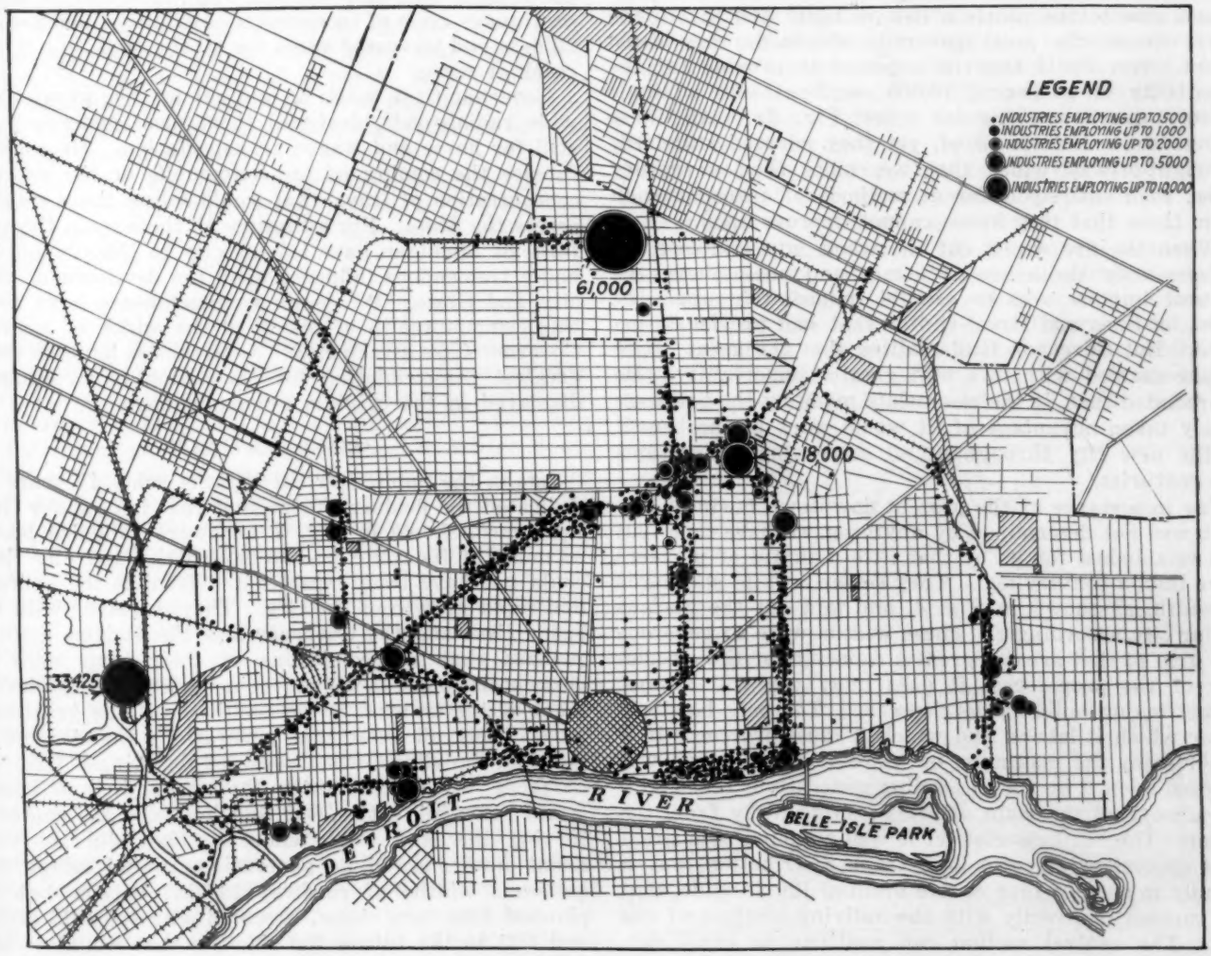

Fig. 3—How the Industrial Plants of Detroit Are Concentrated
This Map Gives Some Idea of the Problem That Has To Be Met in Transporting the Working People to the Factories Each Day

The third outstanding example of far-visioned planning occurred between 1877 and 1883, when a group of public-spirited citizens obtained and dedicated to public use 11.6 miles of right-of-way, varying from 150 to 200 ft. in width, and running from a point opposite Belle Isle on the east, around the outskirts of the city, as then extended, to a junction with the Detroit River, an equal distance on the west.

Early Conditions in Detroit

To realize the full significance of these three accomplishments it is necessary to bear in mind the conditions that existed when the various developments took place. Take the Governor and the Judges' plan first. Detroit was a log village, as indicated in Fig. 2, on the edge of a forest wilderness, with the merest fragment of street traffic to provide for. Its inhabitants could not possibly have visualized the growth into the future city of 1,000,000 or 2,000,000 inhabitants. They could not foresee the towering office, hotel, factory and apartment buildings that would, in effect, pile city on top of city, in multi-storied and multi-peopled blocks. The Hotel Statler handles every day, in a single building, twice as many people as there were in Detroit in 1806. The pioneers could not anticipate the electric street-car or the rapid-transit train with their enormous capacity for swift mass-transportation and their ability to concentrate the population of a large city upon a few acres of land. They could not foresee the coming of the automobile that would give to the people a new mobility and tax to the very utmost the most generous standards they could adopt. Nor could they be expected to provide for the possibility of gathering 70,000 employes into a single factory every working-day (See Fig. 3). All these things were undreamed of, yet they adopted standards of right-of-way width that we, more than a century later, with entirely different methods of transportation from those that they knew, cannot improve upon.

When the fire wiped out the whole city and left the citizens only the ashes of homes and possessions, the natural impulse was to rebuild immediately upon the exact lot-lines and street-widths that had previously existed. But Governor Hull realized that the great catastrophe carried with it a still greater opportunity. He appreciated that, if the clean slate made by the fire were wisely taken advantage of, it would work to the benefit of the new city throughout all succeeding generations and centuries.

The importance of the present downtown business district was not determined by anything we have done but was established for us by that little handful of pioneers more than a century ago. They set up certain standards of width, as shown in Fig. 4, and laid out the nucleus of our city accordingly. These widths were so generous and give to that area so great a capacity for the circulation of the people that it does now, and will always, attract major building development. The only handicap under which it labors, and which it must overcome if it would enjoy the maximum of usefulness and value, was imposed upon it by the succeeding generations that throttled almost all the main arteries leading away from the center. The business district is well supplied with great open spaces for its own local traffic-distribution, but it is sadly in need of four or five avenues 120 ft. wide, that will connect it directly with the outlying sections of the city. The central section can continue to erect sky-scrapers for a long while before it will exhaust its own local street capacity; but its real problem lies in the many bottlenecks to traffic with which it has been almost completely surrounded.

Fragments of Original Plan Still Exist

That the plan of the Governor and the Judges was not carried out as the city grew, does not discredit the plan, but only those who failed to live up to it. Only one, and that a secondary thoroughfare, namely, Jefferson Avenue, was continued for many miles at the width then established. Jefferson Avenue is today the only continuously wide street on the east side of the city. It is impossible to calculate the influence of this great thoroughfare upon the development of the many large industrial and fine residential districts that it traverses and serves. For instance, it has, hand in hand with the automobile, made possible the marvelous development of the villages clustered along the Grosse Pointe shores.

Imagine Jefferson Avenue reduced to the width of Gratiot Avenue, and that the traffic conditions of Gratiot Avenue existed along the length of Jefferson Avenue. It is inconceivable that Grosse Pointe, as we know it today, should exist at all. Grosse Pointe derives its present importance and great value, as a residential district of the highest class, from the fact that Jefferson Avenue makes its lake shore readily accessible to the heart of Detroit. Cut the width of Jefferson Avenue in half and the resulting congestion would become so intolerable that Grosse Pointe property would become a drug on the market. Cut another Jefferson Avenue 1 mile away from the present one, and you will start into motion another continuous cycle of increased accessibility, increased usefulness and increased value for all the land that it would reach or serve.

Governor Cass, when he laid out his five great 100-ft.-wide radial-roads, designed them most generously, but still for horse and wagon transportation. He could not foresee the coming of the automobile or the enormous concentration of travel that would follow these shortcuts across the State. For a century all these main thoroughfares of Michigan have led directly to Detroit and have had a tremendous influence upon the development of our city and State. Wholesale encroachments have robbed this commonwealth of one-third the width of highways Governor Cass established. Nevertheless he deserves the greatest commendation for the vision and courage he displayed in the original accomplishment.

Grand Boulevard

Again, the public-spirited citizens, who, 41 years ago, dedicated the field and farm land that is now our Grand Boulevard, shown in Fig. 5, and were ridiculed because so much of its route was so far outside the city limits, could not have been expected to visualize the enormous and rapid growth of the city. They, together with Governor Cass and the Governor and the Judges, evidently realized that the conditions of their time were only momentary phases, instead of a finality, in the development of the transportation facilities of this great territory. They all knew that generations would come and go, that buildings would succeed buildings, that road surfaces would constantly change, and that hamlets would grow into cities, but that land and the routes for serving the land would endure. They did not worry about how succeeding generations would adapt these generous widths of roadway to their needs, but they planned with rare vision, executed with splendid courage and left to the future the changes that would occur in the people, the buildings and the types of transportation. The great usefulness of the routes, and of the widths

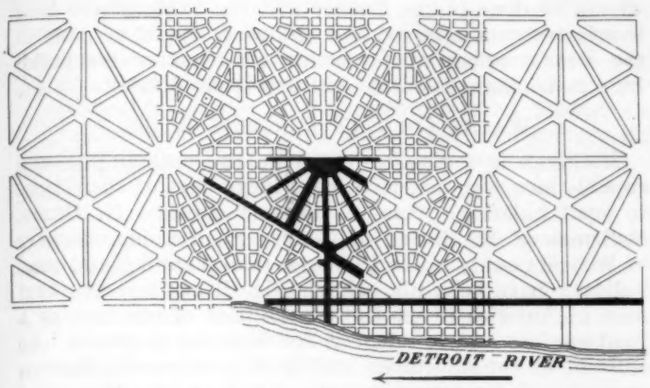

FIG. 4—ORIGINAL PLAN OF THE CITY OF DETROIT
This Was Drawn Up by Abijah Hull in 1807 and Provided for Three Classes of Streets, Main, Radial and Residential, Each Having a Definite Width

that we inherit, will go on proclaiming the merit of their worth throughout all time.

With the exception of these three outstanding examples of major planning, Detroit has grown out along its radial arteries and its railroads in a more or less haphazard misfit manner. Until recently, no master plan has existed to which subdivisions, within and without the city, have been made to conform. Little or no consideration has been given to continuous through-routes, uniform widths, proper alignment, the elimination of offsets and dangerous angles, or to the providing of a suitable balance between streets of major importance and generous width and those of a purely local character. What little planning has been done has been disconnected, and all has been based upon the standards of man and horse transportation.

This, in brief, was the situation preceding the coming of the automobile. Now let me say a word about the reasons for the popularity of the automobile and about its further adoption and use.

CHANGES PRODUCED BY THE AUTOMOBILE

The railroad train, the steamship and the trolley-car are essentially for mass transportation. They require heavy investments and reasonably favorable conditions for operation. They are to a certain extent inflexible; the individual must in a large measure make his needs fit the service that is offered. The automobile, on the other hand, is for the individual rather than for the mass. It is flexible and makes it owner practically independent of all things except weather and road. Man has created for himself a mechanism to take the place of the horse, and in this mechanism he has combined the speed of the railroad train with tireless capacity for travel.

Originally regarded as an expensive luxury, a plaything of the rich, the automobile has become, through marvelous methods of manufacture, the magic carpet of transportation for all mankind. The range of action of the horse and buggy was very limited. With it man moved slowly within a restricted area. The opportunity to sell his services and his products was circumscribed by transportation restriction. But the automobile offers to the individual a tireless speed and an infinitely greater radius of action. To its owner, the motor car is a railroad train and a trolley-car combined. It has increased his ability to earn, and that of his family to enjoy life. It was inevitable, consequently, that, once sensing these advantages, civilization not only would never relinquish the motor vehicle, but would rush overwhelmingly toward its universal adoption.

In 1913, approximately 1,250,000 automobiles were registered in the United States. This number was increased 12 times in the succeeding 10 years and, as was to be expected, the increase has been going on at an accelerating rate. Last year, in Wayne County, the home of the automobile, after 20 years of familiarity with its advantages and continuously enlarging additions to its ownership, the registration of passenger cars was increased by 53,000. It is difficult to visualize so large a number, and to realize that it is the increase of only a single year in one county.

Fifty-three thousand vehicles means a seating capacity for 265,000 persons, the equivalent of the combined populations of Flint, 118,000; Pontiac, 45,000; Port Huron, 26,000; Ann Arbor, 23,000; Wyandotte, 22,000; Royal Oak, 16,000; and River Rouge, 15,000. Imagine that the inhabitants of all those places were loaded into 53,000 cars and that the cars swung into Woodward Avenue at Grand Circus Park. At the maximum rush-hour rate per lane of traffic, as shown by the recent count of the Police Department, it would require seven and one-half 12-hr. days for the last vehicle to reach Jefferson Avenue.

Fifty-three thousand automobiles, each occupying 26 ft., would make a 265-mile procession. Parked at the curb, on both sides of the roadway, but clearing fire hydrants and crosswalks, they would require a street 86 miles long. Of what use is it to talk about shaving sidewalks for a few blocks to help the parking situation, when 1 year's increase would require both sides of an 86-mile street? The city-traffic problem is the most serious one that confronts the automobile-using public and the motor-car industry today. Great improvements can be made at relatively low cost in the open country, but the cost of the necessary measures for relief in the thickly built-up sections is enormous.

The occupants of 1 mile of automobiles represent a section of society, with all its manifold tastes, needs and capacities for purchase. Every mile of automobiles can be translated into a certain potential purchasing-power. That power is generally exercised by the individual within the radius of action that his transportation facilities prescribe. If that radius of action were sud-

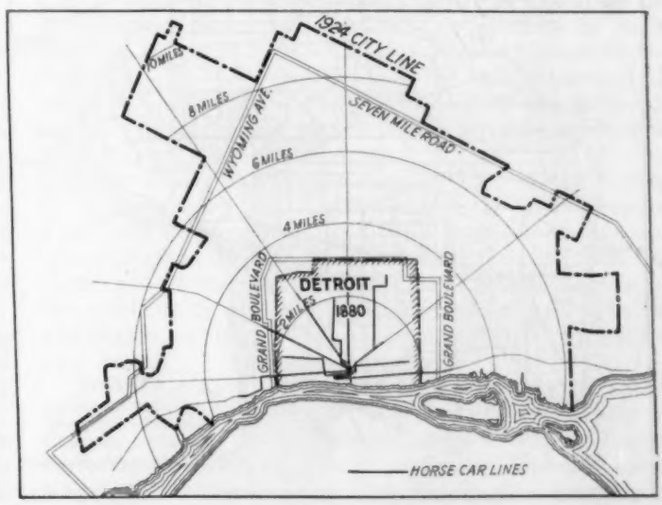

FIG. 5—RELATION OF THE BOULEVARDS TO THE CITY OF 1880 AND 1924
This Sketch Shows the Relation of the Grand Boulevard to the City of 1880 and the Proposed Wyoming-Seven Mile Superboulevard to the City of 1924

denly increased 10 or 20 times, his purchasing power would be made available over the greater area. This capacity for purchase is made available to all property, industry and business over the whole area that can be reached by his automobile.

Land Made Accessible

Land that is inaccessible to man is of no value, regardless of what it may contain of fertility, oil, minerals, timber, or the other things ordinarily useful to man. If the land is inaccessible, man cannot make use of the things that it contains. Accessibility, therefore, is the first essential to be considered in determining the usefulness and value of land. The automobile makes land accessible, more useful and consequently more valuable. It is the greatest distributor of land values that the world has ever seen. The most available proof of this is to be found in the territory surrounding large centers of population. Wipe out the automobile and you will wipe out hundreds of millions of dollars of the value of land that is dependent upon the automobile for its accessibility, its usefulness and its value.

Whatever makes land inaccessible lessens its value, and whatever makes it more accessible to more persons increases its value. Fifty-three thousand new automobiles, added to Wayne County's registration last year, with the new mobility that they give to their 265,000 passengers, have a directly enhancing influence upon the value of all the land in and adjacent to Wayne County that can be easily reached by them. Like a flood that nourishes wherever it flows, this great stream follows the paths of least resistance and leaves a profit in its wake.

This Detroit area, shown in Fig. 6, which has benefited so enormously from the general adoption of the automobile, is confronted with a serious motor-vehicle transportation problem. Having developed the automobile, it is now our duty to lead the way in providing the new facilities required for its use.

The problem may be divided into two parts: (*a*) what should be done in the County and the State where land is relatively unimproved and (*b*) what should be done in the older portions of our cities, where expensive buildings make changes costly and extremely difficult.

Fig. 6—Roads and Highways in the Vicinity of Detroit
On This Are Shown the Unimproved Roads, Those That It Is Proposed To Pave and the Improved Roads. The Proposed Superhighways Are Also Indicated

Wayne County's Concrete Roads

Michigan is fortunate in having two outstanding and capable men who are devoting a large part of their time to road building. One of these is Edward N. Hines, chairman of the Board of County Road Commissioners of Wayne County. For 19 years, road planning and road building have been his hobby. Mr. Hines was the first man in America to see the possibilities of concrete as a road surface and to adopt it for highway purposes. In spite of all the difficulties with public sentiment, finance, methods of construction and opposition by other road interests, he has steadfastly adhered to the type of surface that he had proved to be the cheapest and best in the long run.

Any man can accomplish much if he sticks to one thing for 19 years. But few men have the sense of public duty and the tenacity of purpose of Edward N. Hines with his concrete roads. With able commissioners and an able engineering staff to support him, he has given to Wayne County 400 miles of improved roads, of which 365 miles is of concrete. This is a better showing than can be made by any other county in this or any other country. It is a world's record. Fifty bridges have been built, two of them costing more than $1,000,000 each. Eight important grade separations have been completed, and six more are either under way or planned.

The minimum width of the concrete roads Mr. Hines is building today is 20 ft., but all the present plans provide for an ultimate minimum width of 40 ft. Wayne County has learned the lesson that facilities for motor-vehicle transportation create more transportation. The Commissioners appreciate the irresistible movement of the people of our time toward the universal adoption and use of the automobile. They realize that half-measures are useless under the present rapidly changing conditions and are planning just as boldly as the urgency of the situation demands. Forty feet of concrete represents four lanes of travel. The surfaces, 10 in. thick at the edge and 8 in. in the middle, are capable of safely carrying the heaviest vehicles that are allowed by our present State law.

Wayne County is also actively at work acquiring wider rights-of-way along the great trunk-lines, to allow the laying of two separated roadways, each of four-lane capacity. For, in spite of the great advantage of 19 years of continuous effort applied to the solution of this one problem, the demands of the traffic are always ahead of the Commission's capacity to build the roads.

Building by Routes

The other outstanding figure is Gov. A. J. Groesbeck. I shall not attempt to catalog all his many accomplishments for this State in connection with road-building. It is enough to say that, since the time of Governors Hull and Cass, no other State executive has given evidence of so complete a grasp of the state-highway needs of Michigan as has Governor Groesbeck. Simple though it may seem, it required Governor Groesbeck to reestablish the fundamental laid down by Governor Cass, that roads should be built by routes, and not as disjointed sections all differing from one another according to the caprice of the authorities in the political subdivisions through which the route passed.

Governor Groesbeck realizes, from his intimate

knowledge of the traffic problem in all parts of the State, that the greatest volume in numbers and the greatest mass in tonnage originate in the large centers of population, and that through-routes connecting them with one another require more generous widths, heavier construction and wider rights-of-way and road surface than any other roads not serving so heavy traffic.

The influence of continuous through-routes of travel upon the development of the territory traversed is best illustrated by a study of the map of the Lower Peninsula. Follow the five great radial-roads laid down by Governor Cass, and note the cities that have been developed along their rights-of-way. The total population of all the cities in the Lower Peninsula of over 8000 inhabitants each is 2,082,000, while the cities on these five great trunk-line roads aggregate 2,004,000, or more than 96 per cent of the total. These radial roads helped to reclaim the wilderness and to start settlements, villages and towns. Railroads sought the larger centers and added to their growth. The highway that was originally the only means of communication, and was responsible for the beginnings of these various cities was later replaced for distance travel by the railroad and the trolley-car. Today, the situation is being rapidly reversed, and the road is again assuming its original position as an important means of intercity and distance travel. The trunk-line highway system may well be regarded as a network of publicly owned "railroads" made available to the entire population of the State for their individually owned rubber-tired transportation equipment.

Further study of the map will show that Woodward Avenue, or M-10, as its extension across the State is called, serves a larger population than any other of Governor Cass's radials. Grand River Avenue, however, is a close second, with Michigan Avenue a strong third. Governor Cass, in 1824, at a time when the road traversed a wilderness and Detroit had a population of less than 1500, decided that Woodward Avenue should be 100 ft. wide. Governor Groesbeck, just a century later, has decided that it shall be 200 ft. wide. Instead of a population of 1500, Governor Groesbeck has to deal with one of almost 1,500,000, and, what is a much more serious problem than mere increase of number, has to deal with the new mobility created by the automobile.

Annual Increase of Population

If it were possible to forecast with any degree of accuracy the limit of Detroit's growth and the limit of the adoption and use of the motor car, it would be possible to say with equal accuracy just what plan of streets, roads and superhighways would fit Detroit's future needs. Detroit has been adding in population and in houses a town the size of Dearborn, 5000, every month, and a city the size of Saginaw, 60,000, every year, and has increased her passenger-car registrations 70 per cent in the last 2 years. She is converting field and farm land into city property, and her people are exercising their right to own and use the automobile at so accelerating a rate, that the width of every road and street in this whole area has suddenly become a matter of great importance to all the people.

When Woodward Avenue was first paved with concrete all the way to Pontiac, it was generally thought that this would make adequate provision for the traffic of all time. In less than 10 years, the traffic desiring to use this important thoroughfare increased so far beyond the capacity of the road that the overflow fills every available

Fig. 7—The 204-Ft. Super-Highway

Four Lines of Rapid-Transit Tracks Are Shown in the Center, One Pair Being for Local and the Other for Express Traffic. This Space Is 84 Ft. Wide. On Either Side of the Central Rail-Area Are Twin Motor-Vehicle Roads. The Inner Roads Are for Express Motor-Transport and Are Carried over Cross Roads at Railroad Stations as Shown. The Outer Motor-Roads Are for Local Traffic and Are Flanked by Sidewalks. The Motor Roads Are Each 20 Ft. Wide So That 80 Ft. of Roadway Is Provided for Motor-Vehicle Traffic

alternate route to full capacity on Sundays and holidays. While a hard surface was the first essential to be supplied, increased width went almost hand-in-hand with it.

Governor Groesbeck, with all our newer requirements more clearly in mind, is making Woodward Avenue 200 ft. wide. In the center, as shown in Fig. 7, will be space for rail transportation and, on each side, concrete roadways, 40 ft., in the clear, or, with gutters and curbs included, a little more than 45 ft. each. The total combined width of the two parallel pavements will be 90 ft. Ample space will be available on each side for sidewalks, tree planting and the like. When finished, wider Woodward Avenue will be the mecca of highway engineers and students of motor-vehicle transportation. It will be the first superhighway especially designed and built to meet present motor-vehicle requirements. It will be the second great accomplishment of this century in road-building, and will take its rightful place alongside the Governor and the Judges' Plan, the five great radial-roads of Governor Cass, the dedication to public use of Detroit's Grand Boulevard and the 365-mile system of Wayne County's concrete roads.

Wider Woodward Avenue is a symbol of the future. It is Governor Groesbeck's answer to our greatest Twentieth Century problem. With boldness of plan and splendid efficiency in accomplishment, he has won the confidence of the public in this work. He deserves all the opportunity and all the honor that will go with the completion of the great undertaking that he has so ably begun.

In attempting to answer the question, "What should be done in the County and the State?" I am treating the subject broadly and not with relation to Wayne County or to the Governor's highway program. The first essential should be the creation of a master plan covering all the intercity routes of importance that belong in the trunk-line highway system. These routes are the most important in the State. They may represent only 10 per

cent of the total mileage, but it is estimated by authorities that they carry 90 per cent of the total vehicular traffic. By connecting large centers of population, they make the entire street-systems of each one readily accessible to all the others.

These routes will have varying degrees of importance in the system as a whole, depending upon the population-density that they serve, and whether they are the only direct channels of communication. For instance, a radial road that serves as a shortcut from one large city to another and has no parallel roads for traffic relief, is many times more important than is a north and south or an east and west road that has many parallel routes. The radial road can be increased in capacity only by acquiring additional width, or by laying out an entirely new and parallel route. The meridian road, on the other hand, can be benefited to the extent of 100 or 200 per cent by improving the roads that are parallel to it. This makes it imperative, therefore, that standards of right-of-way width be established and applied to the various routes in the master plan, in accordance with the character and the importance of each to the State as a whole.

The Master Plan

A master plan is of importance to every township, county, village and city. Only by the most careful study of existing and desirable routes within the section itself, and of their relation to similar routes in adjoining areas, particularly the routes of state-wide importance, will it be possible to prepare a proper master-plan. All the careful consideration that must go into this preparation, and the discussion that will precede its adoption, will generally win one-half the battles toward its accomplishment.

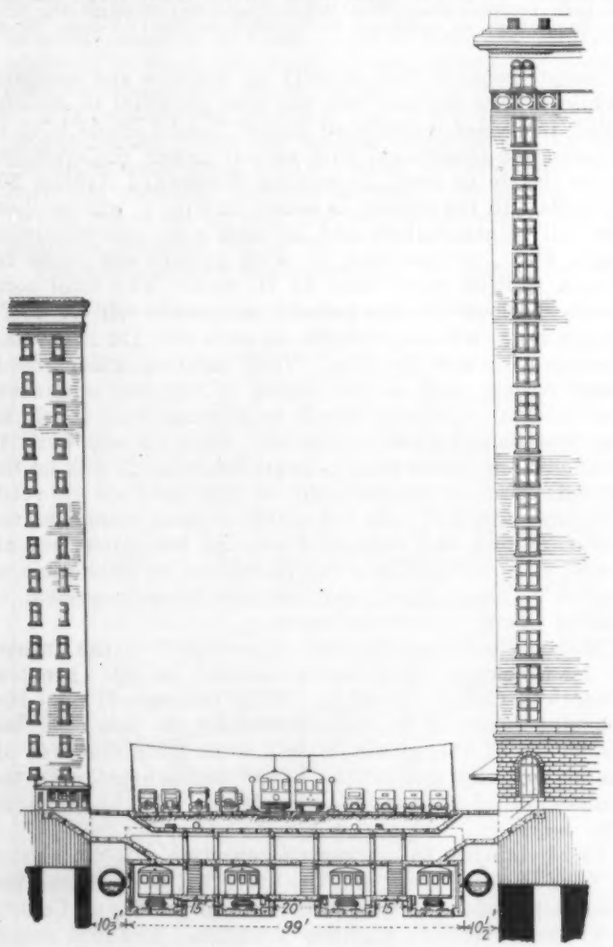

Fig. 8—A 120-Ft. Double-Deck Street
The Upper or Present Street-Level Is 96-Ft. between Curbs and Will Provide Space for Eight Lines of Motor Vehicles, Two Surface-Car Tracks and Two Safety-Zones. On the Lower Level Are Located Two Tracks for Express and Two Tracks for Local Rapid-Transit Lines and Two Main Sewers

The next essential, after having the master plan, and having established the standards of necessary width, is, that the rights-of-way be acquired at the earliest practicable moment. These must be obtained now while land is relatively cheap and before improvements make condemnation expensive or impossible. The development of these rights-of-way can best be determined by the needs of the traffic.

In the Detroit area, after a conference of all the authorities of the three counties of Wayne, Oakland and Macomb, a system of superhighways, lying roughly between the 6-mile and the 15-mile circles, has been laid out. This system comprises 217 miles of 204-ft. right-of-way along routes that for the most part traverse unimproved field and farm land.

The program is to obtain a special act at the next session of the legislature that will create a transportation district embracing the territory served by these superhighways and set up a controlling board properly representing the various sections, with the power to levy a ½-mill tax upon all the property within the district. This board would have no authority to improve but only to acquire the right-of-way by condemnation, purchase or gift.

The purpose is to obtain the necessary additional strips of land along certain strategically important routes while the land is still relatively cheap and easily obtainable. These wide rights-of-way should be carried into the city just as far as the lack of expensive development will allow. Taken all together, the routes selected will make a belt system surrounding the present built-up area and forming the great thoroughfares of the greater city to come. The layout has been most carefully made so that it will not only serve equally all the area traversed but also connect properly with important city-routes within, and with State trunk-lines without the district.

Rights of Way Necessary To Be Acquired

The essential thing is to get the rights-of-way now. Exactly how each of the various routes will be developed cannot be determined at this time. It is certain that increased capacity for motor-vehicle traffic will be the first requirement. This will give a great stimulus to the upbuilding of territory that will again require more facilities for transportation. Some of the routes may serve territory that will be devoted to residences of the very highest class but with so low a population per acre as not to justify train-operated rapid-transit. Others may have great industrial or business concentrations that will demand mass transportation. The system of superhighway rights-of-way will adapt itself to all these different requirements as they develop.

The figure, 204, was arrived at by taking the width, 120 ft., as established by the Governor and the Judges in 1806 for their secondary radial-arteries, such as lower Woodward Avenue, and adding to it 84 ft. for surface rapid-transit. Where interference with the foundations of adjoining buildings is to be avoided, and main sewers must also be provided for, 120 ft. is the desirable width for a four-track underground line. The expense of underpinning, on streets too narrow properly to house the transit structure, is a total loss, whereas the same money spent in widening the street is a permanent asset.

A 120-ft. street, with a four-track line beneath it, as shown in Fig. 8, may be looked upon as a double-deck, or two-level, thoroughfare. If, at the edge of the built-up area of the city, the four tracks are brought out from below ground and are laid upon the surface with grade separations every ½ mile and, if the former 120-ft. street is divided into two 60-ft. sections, that are placed one on each side of the surface-transit facility, we shall have a single-level street with the same four transit-tracks and the same 120 ft. for vehicles, pedestrians, tree-planting, and the like. This is shown in Fig. 9.

The main objects sought in obtaining the wider rights-of-way are substantially as follows:

(1) To allow a variety of treatment in pavements, tracks, tree-planting and the like, depending upon the requirements of the territory traversed

(2) To give increased capacity, with increased speed and safety, for motor-vehicle transportation, regardless of any other use to which the highway may be put. This means individual and collective rapid-transit on rubber tires, until such time as the density of the population shall demand rail transportation

(3) Proper spacing of the vehicle roadways, while retaining the center free to provide for future train-operated rapid-transit at a saving of almost one-half the cost per mile of an underground system. By reason of the lower cost, rapid transit can be provided at a much earlier date or, for the same money, over a much larger area

(4) When surface rapid-transit is provided, with grade separations at the station points at ½-mile intervals, the express motor-vehicle roadway can be carried over the same intersecting streets and will provide a facility not now available to motor-vehicle owners anywhere in the world

(5) The wide right-of-way, regardless of the particular form of development that may be used, will have a surface capacity sufficient to take care of the transportation of the occupants of the tallest structures. Being wide, the superhighway will not only invite major improvements of this character but will give them the maximum of light and air and a splendid setting

(6) Regardless of whether the superhighway is developed wholly for vehicular traffic or for vehicular traffic and street-cars or for vehicular traffic and rapid transit, it will allow the planting of trees and shrubbery in places along its route where they will not be disturbed by the successive steps in its development

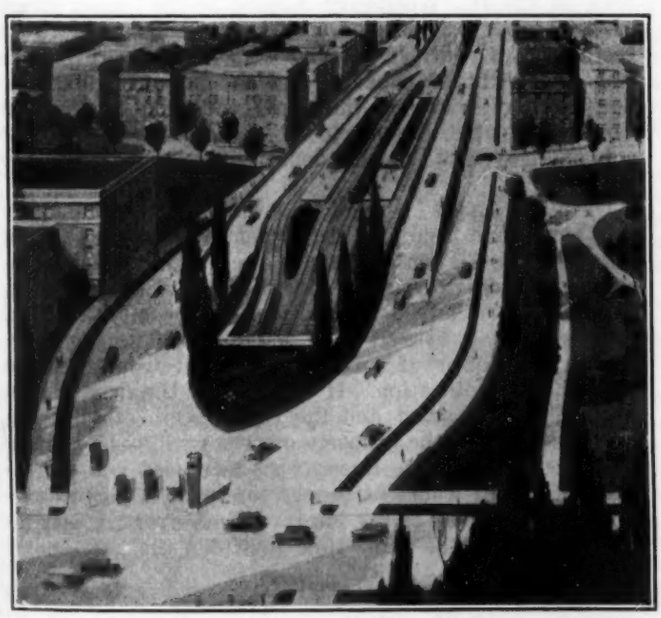

FIG. 9—TRANSITION FROM A 204-FT. HIGHWAY TO A 120-FT. THOROUGHFARE

At the Edge of the Built-Up Area of the City the Four Tracks Are Brought Out from Underground, Are Laid upon the Surface with Grade Separations at ½-Mile Intervals and the Former 120-Ft. Street Is Divided into Two 60-Ft. Sections, One on Each Side of the Rapid-Transit Facilities

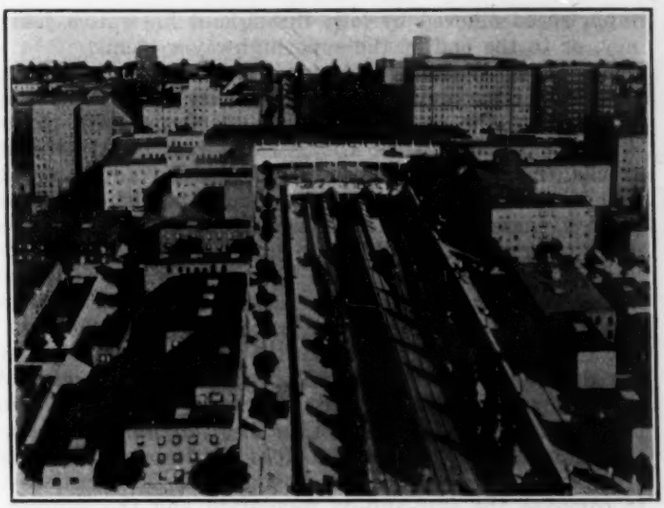

FIG. 10—CROSSING OF TWO SUPERHIGHWAYS

Where Two of These Proposed Boulevards Intersect, the Placing of Each upon a Different Level Will Avoid Any Interference from Cross-Traffic. The Arrangement of the Express and the Local Roadways and the Separation of the Former from the Rapid-Transit Tracks by Walls at the Stations and the Planting of Trees in Between Are Clearly Brought Out

A SUPERHIGHWAY

The superhighway, consequently, will not only combine all the necessary Twentieth Century utility requirements but will allow sufficient tree-planting and landscape treatment to make it a thing of beauty.

To make surface rapid-transit operation safe, the tracks must be upon an exclusive right-of-way, guarded between stations by fences and the plantings of trees and shrubs. At ½-mile intervals the tracks will be slightly elevated, while the intersecting street will be slightly depressed, to make a grade separation of the same character as many of those we now have south of Grand Boulevard. The stations will be located above these grade separations, and passengers will descend through the platforms to the intersecting streets below. The crossing of two superhighways is illustrated in Fig. 10.

The 60-ft. roadway adjoining the rapid-transit tracks will be divided into three parts: sidewalk, local roadway and express roadway. A curbing will separate the local from the express roadway opposite the entrances of side streets. Vehicles may, however, merge from the local into the express-traffic stream and, vice versa, between blocks. At the stations, however, the express roadway would be carried over the intersecting street so that it would be entirely free from "stop-and-go" regulation and cross-traffic interference. No pedestrian or motor vehicle would ever cross the express roadway; consequently, the user of it, running in a straight line parallel to the rapid-transit tracks, would be able to maintain the maxi-

mum speed allowed by law, throughout his entire journey, or to the end of the superhighway system.

On lower Woodward Avenue stop-and-go regulation reduces the maximum recorded capacity of a single lane of traffic to the rate of 440 vehicles per hr. On Fifth Avenue, in New York City, which has no street-car tracks, the maximum capacity recorded for any interval of time was at the rate of 600 vehicles per hr. As congestion increases, vehicular movement will be slowed-down wherever it is subject to crossing interference and stop-and-go regulation.

The superhighway express roadway, on the other hand, should have a maximum capacity per lane of traffic from five to seven times as great as the present maximum in our downtown district. It will restore the motor car to its maximum usefulness and, by greatly increasing the owner's radius of travel within a given unit of time, will make all the land that is along, or is served by, the system more desirable and more valuable. The best way to compare the stop-and-go regulation and the express roadway is to regard the former as the working of a hand-saw, in which a considerable part of the time and effort is wasted, and the latter as a circular saw that cuts continuously as long as material is fed to it.

Improvement of Older Portions of Cities

The other question, What should be done in the older portions of our cities, is infinitely more serious and difficult of solution than is the problem presented in the County and the State. The New York City papers are now describing the new police regulations that will create 253 one-way streets. Buildings continue indefinitely to rise into the air, and more and more subways are being built, but the street space of the old days of man and horse transportation still remain. Sidewalks are shaved, parking is prohibited, and one-way streets are established, but the pressure and the volume of the traffic is always increasing. The very skyscrapers that stand in solid rows and pour their ever-increasing streams of humanity into the old narrow ways are in themselves the greatest obstacle that we have to deal with in providing surface-traffic relief. New York City is today meeting the problems that are directly ahead of us. We may profit by her experience, or we may drift along into the same situation with which she is confronted. Which shall it be?

In the City of Detroit today 36.4 per cent of the area is devoted to streets and alleys, yet, on account of the absence of a master plan to guide its development, we have innumerable bottle-necks, bad alignment, offsets and the like to cause congestion, and more will appear with each increase of traffic. In a typical 3-mile square, surrounded by 204-ft. superhighways, with 120-ft. streets on the section-lines, with 86-ft. streets at the ½-mile points, with all the residence streets 60 ft. wide, only 35 per cent would be devoted to streets and alleys, but the area would be served infinitely better. Although Detroit has a relatively large mileage of 100-ft. streets, the majority of them are short disconnected lengths that do not form parts of through-routes of travel.

What is needed in the city as in the State and in every other political subdivision, is a master plan. This must be made up of a limited number of carefully selected streets, which, when linked together and opened and widened, will form a supergrid that will give equal service to all sections. Such a system, to serve the city properly, would comprise about 250 miles. It is, of course, impossible to finance so great an undertaking immediately.

The first essential, however, is the creation and adoption of the master plan itself. Thereafter, all applications for openings and widenings should first be compared with the master plan. Its very existence would go a long way toward eliminating unnecessary and undesirable expense of this character, by concentrating all effort and all money upon the lines laid down in the plan.

Such a map of interior thoroughfares has already been drawn for the city of Detroit by the City Plan Commission, in collaboration with all the other commissions and authorities concerned with this subject. This plan shows clearly how an opening here, the elimination of an offset there, a new grade separation or a viaduct somewhere else would complete a system of north-and-south and east-and-west through-routes of travel. At first, they would be routes only. Our congested conditions would be immediately relieved to a considerable extent by concentrating first upon the isolated spots that now prevent through-travel, along lines that a study of the map and of local conditions shows to be the most logical. No opening or widening that is a part of the master plan should be made, unless it be the full width that has been standardized and adopted as part of the plan itself.

Manner of Widening Streets

The widening of the different routes in the plan can be brought about in either one of two ways:

(1) Where the route is of vital importance and the improvement is essential at once, it should be accomplished by the usual condemnation proceeding

(2) Where the improvement is not immediately necessary, it may be accomplished through the adoption of set-back lines and an agreement between the city and the property owners upon a date on which the widening will be made effective

Woodward Avenue, from Grand Circus Park to Palmer Park, and Gratiot Avenue to Connor's Creek, are outstanding examples of routes that should be widened at once to 120 ft. Woodward Avenue is the "main street of Michigan." It bisects the city and deserves to be restored to a width in keeping with its strategical position and with the capacity and the importance of the downtown district and the great widening in Oakland County. Gratiot Avenue is the sole radial on the east side and traverses the most densely populated area of the city.

Openings and widenings that have been made up to this time have been considered very largely as of local interest only. When a program such as the accomplishment of the master plan is considered, it is obvious that, inasmuch as it affects all sections of the city, it is of interest to the whole city and not to a local section only. The present basis of spreading the cost would require substantial modification. If the lines of the master plan were all 1 mile apart and the routes were of generous width, so that all the property owners within the square-mile would seek those lines as an increased transportation facility, it would be proper to spread a larger proportion of the cost of the improvements over the city as a whole and at the same time to widen the assessment district itself.

Where set-back lines are established by property owners' agreement with the city, it would be necessary to set-up two or three rules governing the special conditions that would be encountered. For instance, blocks having no improvement in front of the proposed line should conform to it with regard to all new buildings. Where substantial structures already exist to the old

line and new buildings are erected in the same block on the new line, the property-owners should be granted the right to bring temporary one-story extensions out to the old line, so as to present a uniform street-front during the agreed-upon period for widening. Whatever property is of so shallow depth that the widening will destroy its value, it would have to be handled as a special case, the property being taken and the owner compensated at once.

In closing, I wish to emphasize the importance of having a master plan and standards of width to fit it, not only for the State trunk-line highway system, but for every political subdivision of Michigan. The time to make the plan is now, and the time to obtain the rights-of-way is at the very earliest possible moment. The great squeeze of street traffic is well under way in Detroit and in all other large cities. Our American method of building straight up into the air, instead of spreading out over a larger area, as in Europe, is bound to result in a concentration of population per acre that will produce intolerable congestion unless a master plan is adopted for traffic relief and efforts are centered upon its accomplishment.

We pay for adequate plans and for their execution, even though we do not have them. We pay in retarded development, in traffic delays, and in loss of time, property and life. The Russell Sage Foundation has made a survey of New York City's traffic congestion and has found that it costs that city approximately $1,250,000 daily, or almost $400,000,000 per year. To just that extent New York City is at a disadvantage in competition with other cities that do not carry such a burden of waste.

The average of all the figures submitted in the Dix-High-Waterloo widening case is $1,122,000 per mile, whereas the widening of Michigan Avenue in Chicago cost $7,000,000 per mile. If we adopt a wise plan at the beginning, time will work rapidly in our favor. Improvements will proceed with greater confidence by reason of the existence of the plan and the whole area will benefit accordingly.

PANAMA-CANAL TRAFFIC

THE growth of Panama-Canal traffic, since the waterway was thrown open to commerce in 1914, is shown in the accompanying table. It will be observed that in only two years, 1921 and 1922, the west-bound traffic exceeded the east-bound. In the last 2 years, due to the heavy movement of petroleum, grain and lumber, Pacific-to-Atlantic cargoes have been vastly greater than those originating on the European and American coasts of the Atlantic. The first full fiscal-year of Canal operation was that ended June 30, 1916. Traffic in the year just closed was nearly nine times as great as it was 8 years before.—*Mercantile Trust Review*, San Francisco.

Fiscal Year Ended June 30	East to West, Tons	West to East, Tons	Total, Tons
1915	2,070,993	2,817,461	4,888,454
1916	1,369,019	1,725,095	3,094,114
1917	2,929,260	4,129,303	7,058,563
1918	2,639,300	4,892,731	7,532,031
1919	2,740,254	4,176,367	6,916,621
1920	4,092,516	5,281,983	9,374,499
1921	5,892,078	5,707,136	11,599,214
1922	5,495,934	5,388,976	10,884,910
1923	7,086,250	12,481,616	19,567,875
1924	7,860,100	19,134,610	26,994,710

INCREASED EXPORTS OF MANUFACTURES

MANUFACTURES are the chief factor in the growth the exports of the United States are making in the calendar year 1924. Reports indicate that the total exports of the calendar year will exceed those of the preceding year by nearly $200,000,000 and will be practically double those of the year preceding the war. Manufactures alone totaled $1,477,000,000 in the 8 months ended with August, against only $1,369,000,000 in the same months of the preceding year, and formed 56 per cent of the total domestic merchandise exported, against 46 per cent in 1922, 45 per cent in 1910, 35 per cent in 1900, 21 per cent in 1890 and 15 per cent in 1880. The prospects are that the total value of manufactures exported in the calendar year 1924 will approximate $2,200,000,000, against $1,100,000,000 in the fiscal year 1914, making the total of manufactures exported this year exactly double that of the year preceding the war, three times as great as in 1910 and four times as great as in 1900.

The increasing use of foreign material by the manufacturers of the United States is illustrated by the fact that the importation of raw material for use in manufacturing seems likely to approximate $1,200,000,000 in the calendar year 1924, against $633,000,000 in 1914, $276,000,000 in 1900 and $170,000,000 in 1890.—*Economic World.*

COMMERCIAL BANKS IN CONTINENTAL EUROPE

IN the United States the commercial banks are primarily institutions of deposit and discount; they finance the current needs of business, not its capital requirements. Capital is furnished to industry through investment banking houses, holding companies and securities corporations. Some of our banks have established affiliations to own or deal in long-term securities, but this development in the United States is yet comparatively new.

In continental Europe the commercial bank exists primarily and chiefly to finance industry; its function is to promote manufacturing and trade. As a corollary the bank controls through stock ownership the larger number of the enterprises it serves, and practically every important corporate undertaking in continental Europe is controlled in this manner by some bank or group of banks.

The banks suffer no disability from non-liquid assets through their ownership of such stocks and bonds, as the funds they employ in this manner are obtained largely through the sale of their own bonds or long-term certificates of deposit.—F. J. Lisman & Co.

Water Recovery for Airships

By Humphrey F. Parker[1] *Illustrated with* Photographs

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

DESCRIBING how the total weight of an airship becomes less as its flight continues, and how its elevators can be used to keep the airship's nose pointed downward, thus balancing the excess lift by "dynamic lift," the author says that 5 hr. is about the limit of flight for which the too great lightness can be overcome in this fashion safely, explains how different the conditions become on long flights and gives details of the means used to counteract this rising tendency.

Valving of gas to overcome airship lightness is wasteful and costly, especially when the craft is inflated with helium gas but, if this is not done, some substance must be collected and stored at the same rate as that at which fuel is consumed in the engines and the most practicable method seems to be to recover water from the exhaust gases.

Gasoline combustion is analyzed and it is brought out that, for every 100 lb. of gasoline burned, 145 lb. of water is present in the exhaust, varying somewhat with the weather conditions and the composition of the fuel. The problem is to make available, as ballast, two-thirds of the water known to be present. How it is present is explained and means for its utilization discussed.

Experimental work that led eventually to the equipment of the airship Shenandoah with water-recovery apparatus is revieweu and the results following its installation are stated.

WHEN starting on a flight, an airship is in approximate equilibrium; that is, the lift exerted by the gas within its gas cells approximately equals the total weight of the craft, including the deadweight of the ship's structure, the ballast, the crew, the useful load and the fuel. As the flight proceeds, this weight becomes gradually less, owing to the consumption of fuel, and the ship becomes light. If no steps were taken to correct it, the first effect would be that the ship would rise, and this would be accompanied by an expansion of the gas within the cells. These cells are normally only partly full but, with increase in altitude, a point is reached where the confined gas expands until it completely fills them. This is known as the "pressure height." Any further expansion would cause increased pressure, which is avoided by providing automatic valves that permit the escape of gas under slight excess pressure. Therefore, with the burning of fuel the ship would rise to her pressure height and gas would gradually escape through the automatic valves. Actually, the ship would be kept at whatever height it was desired to fly her by using the elevators to keep her nose pointed downward, thus balancing the excess lift by negative "dynamic lift," due to the air pressure on the top of her hull that tends to force her down.

On short flights, this expedient is satisfactory; and it is even possible to land a ship considerably light by driving her down in this fashion until the landing party has her in hand. With 200 to 300 men available for this purpose, this can be accomplished readily; but the degree of lightness that can be overcome safely in this fashion is limited. This limit is reached after a flight of about 5 hr. Consequently, on ships making short flights only, this lightness is not a matter of much concern; but, on long flights, conditions are very different. It rapidly becomes impossible to maintain equilibrium by the use of the elevators, and lifting gas has to be valved. With hydrogen, this is not serious, for the gas is cheap and can be replaced when the ship returns to her base. This procedure, however, cannot be adopted with helium because not enough of the gas is available. Even if enough were available, the cost of operating with it on long flights without special measures to conserve it would be excessive. On the Shenandoah, operating at cruising speed, with five engines at 1200 r.p.m., this cost would be $1,000 per hr., assuming that the helium costs 13 cents per cu. ft. This is a very conservative figure at present as it represents merely the cost of producing the gas plus an allowance for transporting the heavy cylinders to Lakehurst, N. J., but it neglects all overhead charges. Ultimately, it may be possible to get the cost down to 5 cents per cu. ft.; but, even at this figure, it will still be necessary to prevent its waste by old methods of operation.

Wastage of Helium

Primarily, therefore, the problem is to prevent the wastage of helium. It is often suggested that the gas might be taken out of the cells, compressed and stored on board the ship. While this is possible theoretically, it is altogether impracticable. On a flight of 24 hr. with the Shenandoah, the volume that would have to be handled in this fashion would be about 150,000 cu. ft. After compression to say 1800 lb. per sq. in., the gas would have to be stored in cylinders; and, even at this great pressure, the number of cylinders required would be 1000 and they would weigh 130,000 lb., a weight as great as the gross lift of the ship. This refers to cylinders of the type used for transporting helium on the ground, but the weight could not be reduced without dangerously lowering the factor of safety. Machinery to compress the gas would also involve very considerable weight, and space would have to be found to store the cylinders. The possibility of reducing the lift by compressing the gas can, therefore, be dismissed as impracticable.

It is desired not to valve the gas on account of its cost; so, as the ship must be kept in equilibrium, something must be done to keep the weight constant. Therefore, some substance must be collected and stored at the same rate as that at which fuel is consumed in the engines. The most practicable method seems to be to recover water from the exhaust gases of the engines. The necessary water is there, and it has been demonstrated that it can be recovered. So, it is of interest to explain just where it comes from and how it is made available.

Water from Exhaust Gas

Consider what happens when 100 lb. of gasoline is consumed by the engine. At the carbureter, the fuel is

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vaporized and mixed with air. Under efficient operating conditions, the amount of air involved is such as to give a mixture-ratio of 15 lb. of air to 1 lb. of fuel, by weight. For every 100 lb. of fuel, 1600 lb. of mixture is drawn into the cylinders.

Air consists chiefly of nitrogen and oxygen, in approximate proportions of 77 and 23 per cent respectively. A small quantity of water vapor is also present; not enough in itself to give all the water needed, though it makes the task of recovering the required amount somewhat easier. Under average atmospheric conditions, say 60 per cent humidity at 60 deg. fahr., about 1 lb. of water vapor is present in 2000 cu. ft. of air, or 10 lb. in the total of 1500 lb. taken in with the 100 lb. of gasoline.

Gasoline consists of carbon and hydrogen in the form of a liquid hydrocarbon. The fuel not being an exact chemical compound, the exact composition varies with the source of the fuel and the method of distillation, but analysis shows that it is made up of about 85 per cent carbon and 15 per cent hydrogen by weight. Therefore, in a mixture of 1500 lb. of air and 100 lb. of gasoline entering the cylinders, we have

	Lb.
Nitrogen	1,147
Oxygen	343
Water Vapor	10
Carbon	85
Hydrogen	15
	1,600

Results of Combustion

In the engine cylinders, combustion occurs and a rearrangement of these elements takes place. It is not necessary to attempt to explain the detailed chemical changes as they occur, but merely to consider what comes out of the exhaust-ports.

First, the carbon burns to carbon dioxide; that is, each atom of carbon present attaches to itself two atoms of oxygen. Now the unit weight of the carbon atoms is 12 and that of the oxygen 16; so, for each atom of carbon originally present, a molecule of carbon dioxide, CO_2, has been formed that weighs 44. In other words, the weight of the carbon dioxide formed is 44/12 times that of the carbon originally there; or 312 lb. is formed from the original 85 lb. of carbon.

Similarly, the hydrogen combines with the oxygen, though in this case two atoms of hydrogen are only able to capture one of oxygen between them. The unit weight of the hyrdogen is 1, so the two atoms, weighing 2, with the oxygen weighing 16, have formed a molecule of water, H_2O, weighing 18. Therefore, the water formed weighs nine times as much as the hydrogen it was made from; so, 135 lb. of water has been manufactured within the cylinders. The nitrogen-content remains unchanged; so, the result of the combustion is

	Lb.
Nitrogen	1,147
Carbon Dioxide	312
Water formed in the Cylinders	135
Water Originally Present	10
	1,604

The total should be 1600 lb. exactly; the slight discrepancy arises owing to the use of whole numbers throughout. For complete combustion with the fuel composition assumed, the mixture-ratio should have been a little greater than 15 to 1.

It happens frequently that combustion is not complete, usually because insufficient oxygen is present, as is the case with too rich a mixture. This does not appreciably affect the formation of water, as the hydrogen is able to capture its oxygen faster than the carbon, which is left with less than its share. The result is the formation of carbon monoxide and soot; in the former case the carbon has formed a gaseous compound with half the oxygen needed to form the dioxide; in the latter, it is left without any.

The point to note is that *for every* 100 *lb. of gasoline burned,* 145 *lb. of water is present in the exhaust.* This quantity varies somewhat with weather conditions and also with the composition of the fuel. For gasoline, 135 lb. can be set as the minimum and 150 lb. as a fair maximum; but, with other fuels, the amount of water formed may be greatly different. Thus, with benzol, it is only 70 lb. and, with alcohol, 115 lb.

Recovery of Water Formed by Combustion

The problem of water recovery from gasoline or fuel of similar composition is to make available two-thirds of the water known to be present. It is present at the exhaust-ports but is very definitely not available because the temperature is in the neighborhood of 1600 deg. fahr. It is obvious that it is not available above 212 deg. fahr., for, at best, it would be steam and, as no means is known of extracting steam from the accompanying gases at high temperatures, the whole volume of exhaust must be cooled at least to 212 deg. fahr. It is not available even at this temperature, however, because it occupies too large a volume and must remain in suspension as vapor unless either the temperature or the volume is reduced. It is not feasible to do anything with the volume, since at 212 deg. fahr. this is about 27,000 cu. ft.; so, the temperature must be reduced further until the saturation point is reached.

The volume under consideration is able to hold in suspension 1000 lb. of water vapor at 212 deg. fahr.; so, with only 145 lb. present, its relative humidity is relatively low. At 125 deg. fahr., however, the 145 lb. is sufficient to saturate it, and this is the temperature at which the first water becomes available. What happens is similar to the formation of a cloud in the atmosphere. The moisture can no longer be held as a gas and is thrown out in the form of minute particles of fog. This process of forming fog particles continues as the temperature is lowered, enough vapor always remaining to saturate the volume at a given temperature and the rest being thrown out.

At 85 deg. fahr., the amount that can be held in suspension is 45 lb.; and it follows that the remainder must be in liquid form. As 145 lb. was present originally, this difference is 100 lb. and it is seen that, if the exhaust be cooled to 85 deg. fahr., a weight of water can be recovered from it equal to the weight of the fuel consumed. If the cooling be carried further, more than 100 lb. is thrown out, and it becomes possible actually to increase the weight of the airship in flight. At 60 deg. fahr., only 18 lb. can be held in suspension; so, if the exhaust be cooled to this temperature, it is possible to recover 127 per cent of water.

The water exists first as fog, which cannot conveniently be collected. However, as this fog moves along in the supersaturated atmosphere, the particles coalesce to form water-drops so that, at the exit, probably 75 per cent is available as liquid. The remaining fog can be rendered available as water, by mechanical means. So much for theory.

The problem resolves itself into a straightforward cooling proposition which, at first sight, seems not very difficult. The most obvious thing to do appears to be

to apply steam-condenser practice, using either a surface or a jet condenser. The conditions, however, differ from those met with in steam condensers in two important particulars.

First, condensing steam is usually a non-continuous process; that is, the heat is transferred from the steam to the water, and the heated water is rejected, a fresh supply of cold water being available as the process is continued. On a steamship, where an unlimited supply of cold water is available, this is perfectly satisfactory; but, on an airship, if the heat were transferred from the exhaust gas to water, that water would have to be used again and, before that could be done, it would have to be brought back to its original temperature by passing it through a special radiator to dissipate it into a medium that can be rejected without affecting conditions on the ship; in this case, the medium is air. Such a radiator would involve considerable weight and head-resistance and, in addition, would be detrimentally affected by the cost and the oil present in the recovered water. The latter trouble is so serious that, unless special measures are taken to eliminate all foreign matter, the efficiency will be cut in half after a few hours of running.

The transfer of heat direct from the exhaust to the atmosphere must therefore be considered. At first sight it appears unattractive, since at least 12 times the surface is necessary as compared with exhaust to water, or say six times the surface required for the double transfer, first to water, then to the air. Actually, it has been found that, though the surface is large, the weight is not excessive. Incidentally, the apparent inefficiency offers a means of escape from the fouling problem. In the case of a water-cooled condenser, a deposit of soot 1/200 in. in thickness is sufficient to cut the efficiency in half; with the air-cooled type, the deposit necessary to do this is 1/16 in. thick and this, spread over the larger surface, represents a very considerable accumulation. In units of the size required for the Shenandoah, of 300 hp. each, this 50-per cent loss of efficiency would be brought about by the deposit of 600 lb. of soot in an air-cooled system and by only 4 lb. of soot in the water-cooled type.

Experimental Work

When I began work on this problem at the Bureau of Standards, no information was available except records of one or two unsuccessful attempts. The idea of recovering water from exhaust gas was first suggested in England about 1909 and, in an actual test, a recovery of 52 per cent was obtained. The test, however, lasted ½ hr. only and, at the end of that period, the temperatures were rising rapidly, thus indicating a decreasing efficiency. Later, at the Washington Navy Yard, an apparatus was built which recovered the necessary amount of water. This was never made to run continuously and was much too heavy and bulky to be put on an airship.

In both these attempts, the heat was transferred first to water and then dissipated to the air. In view of the difficulties likely to be encountered in any water-cooled system, a thorough investigation was made into the possibility of an all-air-cooled type. The first step was a theoretical investigation of the heat-transfer between two gases, to obtain some sort of idea as to the diameter, the length and the number of tubes that would give a reasonable efficiency without excessive back-pressure. Where nothing was known, this was a much cheaper method than building first and acquiring knowledge by failure; and, as the design involved unusual proportions, it might have taken some time to arrive at them.

For example, it was found desirable to use tubes of very great length in proportion to their diameter, more than 700 times longer, and an error in regard to the number of tubes would have resulted in either an excessive back-pressure or a low efficiency. On the basis of this investigation, an apparatus was designed for a weight of a little less than 1½ lb. per hp., 100-per cent recovery being expected under average conditions at full power. It was known that it would offer considerable head-resistance, but this was left to be taken care of in a second step, since to have delayed until an apparently perfect design had been obtained would have ended in no results at all.

Two units were built and given thorough tests. The first, after preliminary runs totalling 10 hr., was run for 90 hr. on the ground and averaged 93-per cent recovery; at times it attained well over 100 per cent. It was then installed on an Army airship, the D-3, and put through flight tests for more than 50 hr. It gave a recovery of approximately 80 per cent, the loss being due partly to midsummer weather and partly to mechanical leaks. The other unit was tested for 50 hr. on the ground, and gave similar results. This type of apparatus, which is shown in Fig. 1, was designed for 300 hp. It consisted of 50 tubes of 1-in. diameter, 60 ft. long and of 0.022 in. wall-thickness, arranged in three rows with return bends between, thus occupying a length of 20 ft., its other dimensions being about 3 x 4 ft.

The tests demonstrated that a water-recovery apparatus could be built, and of reasonable weight. In addition, data were obtained that form a basis for future design. The apparatus, however, offered considerable head-resistance, was bulky and unsatisfactory as a structural unit, and gave trouble with the drainage of the recovered water.

Shenandoah Water-Recovery Equipment

This was the state of development in September, 1923, when it was decided to equip the Shenandoah with a water-recovery system. Unfortunately, the installation was wanted in a hurry, and a choice had to be made between merely eliminating the worst defects from the Bureau of Standards' type, equipping the airship with the minimum of delay and designing a more efficient apparatus that probably would not have been ready for the summer operations in 1924. In view of the great loss of helium that would result from operating the Shenandoah for one season without this equipment, the former course was adopted. The greatest dimension of the apparatus was reduced from 20 ft. to 5 ft., and the number of drainage points from 35 to 2; and the new type, illustrated in Fig. 2, is a rigid self-contained structural-unit with adequate provision for any expansion due to heat.

As before, the apparatus consists of a large number of aluminum tubes fitted into cast-aluminum headers that, in this case, serve to change the direction of the exhaust through approximately 180 deg. every 5 ft. The exhaust gas is first directed from the exhaust-ports into a manifold of normal construction. As the engine is totally enclosed within a car, special means are necessary to cool the manifold, and it is covered with an aluminum casing provided with an intake scoop to direct air through the casing and over the manifold. A cut-out is provided on the manifold, consisting merely of a branch pipe with a plug screwed into its end so that, on the removal of the plug, the engine can be operated

while exhausting direct to the atmosphere, and the condenser put out of action. For normal operation, however, the exhaust flows through the manifold proper to a flexible connection to the condenser entrance. This is necessary because the condenser is suspended directly from the hull, and the cars move almost 1 in. from their stationary position when subjected to the thrust of the propellers.

At the condenser entrance is a distributor header, an aluminum casting that spreads the exhaust to the 45 tubes of 1-in. diameter which fit into the header. Each of these tubes has a total length of 70 ft., and the gases must traverse their whole length before they reach a terminal header. There they are again collected and passed through a separator that is merely a tank provided with baffles to arrest the fog particles and prevent them from being swept out with the residual gases of the exhaust. The baffles cause the gases to change their direction of flow sharply and, as the fog particles are heavier than the actual gas particles, they tend, due to their inertia, to keep on in a straight line, while the gases sweep around the corner and out of the exit. Drain pipes permit the condensed water to flow into the engine cars, where are located a filter to remove soot and oil, a storage tank and a pump for delivering the water to a distribution line in the hull. This line leads to the ballast bags and, by opening the appropriate valves, the recovered water can be directed to any bag desired.

The gases enter the manifold at a temperature of about 1600 deg. fahr.; this has fallen to 1100 deg. fahr. by the time the condenser entrance is reached, and to 400 deg. fahr. at the end of the first 10 ft. Condensation starts after approximately 23 ft. of travel; so, it takes twice as much surface to cool the last 40 deg. as is necessary to cool the first 1000 deg. The actual time taken for the process is less than 2 sec.; that is, within 2 sec. of the time the gas leaves the exhaust-port, the water has been removed from it and it has been discharged to the atmosphere. In spite of the high velocity implied by this short period, the back-pressure is less than 1 lb. per sq. in., which is negligible compared to the mean-effective pressure of more than 120 lb. per sq. in. exerted by the engine.

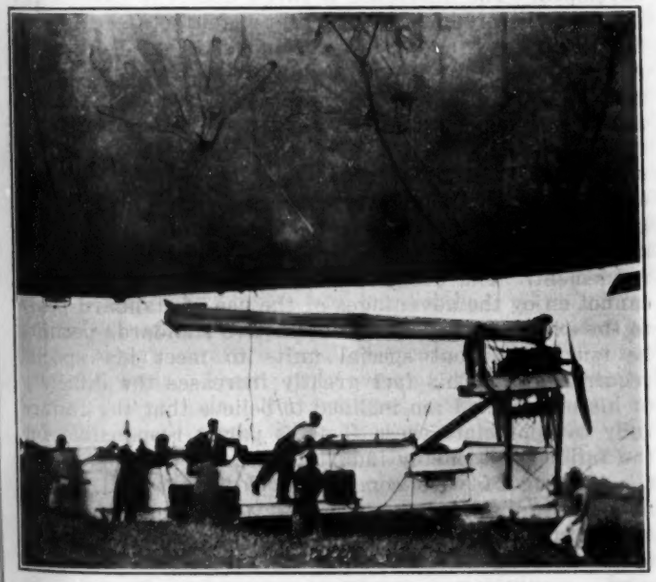

FIG. 1—WATER-RECOVERY APPARATUS INSTALLED ON THE D-3 AIRSHIP This Apparatus, Which Was Designed To Handle the Exhaust from Two 150-Hp. Engines, Consists of 50 Tubes 1 In. in Diameter and Having a Wall Thickness of 0.022 In. Each Tube Has a Total Length of 60 Ft. but, by Arranging Them in Three Rows with Return Bends between, the Space Occupied Is Reduced to 3 Ft. in Height, 4 Ft. in Width and 20 Ft. in Length. In a 90-Hr. Test on the Ground an Average Recovery of 93 Per Cent Was Attained; in over 50 Hr. of Flight-Tests the Recovery Was Approximately 80 Per Cent, the Loss Being Due Partly to Midsummer Weather and Partly to Mechanical Leaks

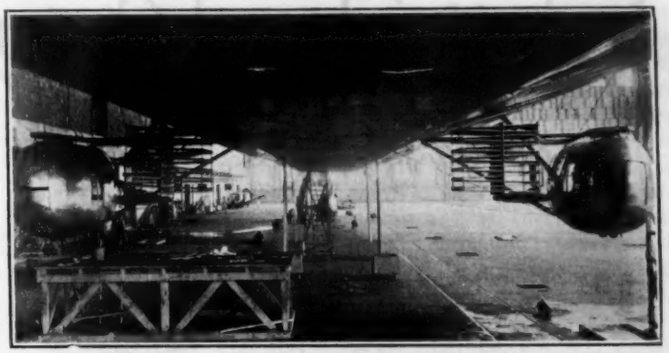

FIG. 2—WATER-RECOVERY SYSTEM INSTALLED ON THE SHENANDOAH This Apparatus for Recovering Water from Gasoline or Fuel of Similar Composition Is Designed To Make Two-Thirds of the Water Known To Be Present Available as Ballast. It Consists of a Large Number of Aluminum Tubes Fitted into Cast-Aluminum Headers and Serves To Change the Direction of the Exhaust Gas Approximately 180 Deg. Every 5 Ft.

The apparatus, which was designed by the writer at the Bureau of Aeronautics of the Navy Department, City of Washington, was built at the Naval Aircraft Factory, Philadelphia. After the assembly of the first unit, ground tests were made at the aeronautical engine laboratory of the Naval Aircraft Factory. The primary object of these, of course, was to eliminate any minor defects that might be present before using the apparatus in flight and also to check its annual efficiency with the design figures. The actual recovery obtained with gasoline was 110 per cent; and the apparatus stood up satisfactorily under its full-load test. This recovery of 110 per cent has since been duplicated in actual flight tests.

Only three of the five engines of the Shenandoah have so far been equipped, as it is expected that these, operating at a recovery of 110 per cent, will suffice for flights of up to 18-hr. duration, allowance being made for landing the ship light. These three units, together with water-delivery lines, storage tanks, exhaust connections, and other incidental parts, weigh 1500 lb. This may seem a serious reduction of the useful load, but it is not necessarily a loss. Ballast must be carried on an airship for use in possible emergencies in landing the ship. It may not be needed at all, but careful piloting requires that it be available. A fair figure for the amount usually carried is 5 per cent of the gross lift. In support of this it might be mentioned that the R-34, in crossing the Atlantic, carried more than 3 tons, or more than 5 per cent. In that case, if ever, it was imperative to reduce the ballast to the absolute minimum. This figure represents 6500 lb. for the Shenandoah. Without the water recovery, this must be taken on at the start of the flight; with water recovery it can be manufactured en route so that, instead of reducing the useful load, the installation of water recovery may materially increase it.

However, the present installation is crude in many respects, it having been built to reduce the loss of helium at the earliest possible moment. It fulfilled that purpose, but is still too bulky and offers too much head-resistance. It was, nevertheless, a definite step forward to accomplish the recovery of more than 100 per cent of water while in the air. With the apparatus now being designed for the ZR-3, it is hoped to secure similar performance with a material saving in weight and in head-resistance.

Industrial and Commercial Applications of the Tractor

By G. D. Babcock[1]

THIS paper was a valuable contribution toward the success of the Chicago Tractor Meeting, held April 24, 1924, and was printed in full in the September, 1924, issue of THE JOURNAL. The discussion following its presentation is printed herewith, preceded by an abstract of the paper for the benefit of readers who do not care to refer to its complete text.

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

AT the close of the war the material and equipment available for the construction of tractors for commercial purposes consisted mainly of the war tractors that were then being produced. It was essential that the tractors should find their own uses. Many parts and many of the mechanical operations of what had been the ordnance tractor have since been changed in adapting it to commercial purposes but the general appearance has remained the same. Heat-treating the cast steel used for track shoes has increased both its life and its strength. The various operations of tractors, including those in timber lands, both in snow and in swamps, are shown by photographs, the industrial rather than the agricultural phases being especially enlarged upon.

Caterpillar trailers make hauling easy but are more expensive than wagons; with tractors they are replacing dog-sleds in Alaska. Winches are used to work over ground that otherwise would be inaccessible.

The life of the track is said to be about 3000 miles but 5000 miles has sometimes been obtained and is the point aimed at. Observations of loose space-blocks in shoes indicated that they gave more satisfactory service than tight ones, so the loose or rolling type was adopted. As a lubricant for the track, grease is used when operating in mud; oil, when operating in dry soil. Changing the position of the holes in the shoes was found to relieve the packing of snow between the sprocket and the track-shoe. The size of the calks also is important and depends on the hardness of the surface of the road. The side-draft of the tractor becomes a grouser problem when the tractor is used in street-cleaning, as in New York City, because the grouser must hold, yet not damage, the pavement.

The use, with tractors, of various accessories, such as rotary snow-plows, timber-cutting machines, road graders and scrapers, and operations such as the scarifying of old asphalt, Southern logging and the swabbing of oil-wells, are described.

THE DISCUSSION

E. B. Clark[2]:—My interest has been more in the line of tractors and similar devices applied within manufacturing establishments. Farm tractors lie in a field in which I have had only a general interest. The problem of applying tractors to industrial purposes is much different from that of their application to farm purposes. Industrial establishments use tractors chiefly to move materials, a branch of their operation that is of great importance even though it is too often given scant attention. For industrial purposes, tractors must be of extremely flexible application; that is, they must be designed so that they will be useful in many ways other than merely towing trailers. In view of these facts, stating to the engineer the problems that he is called upon to solve becomes a difficult task. A manufacturer must conduct his business with a view toward making profits, ultimately if not immediately. Should he enter a field in which ultimate profits are not possible, his efforts are wasted. That being true, he should begin his operations by studying the field carefully with a view toward determining whether the development of devices for that field can be expected to result in profitable sales of the devices after they have been developed. In the industrial field, such study is most difficult; the applications are so numerous and each application differs so greatly from others that work in this field is apt to be discouraged.

The automotive equipment with which we are familiar, that is, the passenger car and the motor truck, are the results of an enormous amount of development. It is true that this development has taken place in the short period of two decades, but it is also true that a great army of engineers has been engaged in the work of development. At present, a standard type has been developed. The difference between different models and between the products of different manufacturers is only one of detail. In going into the industrial field, however, entirely new types must be produced. To do so, the present generally accepted ideas of automotive design must, to a large extent, be discarded. Furthermore, it is to be noted that for the building of a modern passenger-car or a motor truck standard units, such as engines, transmissions, clutches, axles and frames, can be purchased from the parts makers who have developed such units along standard lines to a high state of refinement. The designer of a new automotive vehicle cannot enjoy the advantages of the use of standard parts to the extent that accepted automotive standards permit; he must work out special units to meet his special requirements. This fact greatly increases the difficulty of his problem. I am inclined to believe that the failure fully to appreciate these facts is partly responsible for the failure of so many industrial tractor designs. Only the backing of wise commercial designers and strong financial supporters can provide favorable conditions for successful tractor design, especially as it may be applied to the industrial field.

The mere towing of trailers is only one of the many uses to which a machine must be put if it is to be of use to the manufacturer. Today, one of the principal problems that confront the manufacturer is moving materials within his plant. The problem of internal transportation is really as important as that of external transportation, and is becoming more and more important as

[1] Manufacturing executive, Holt Mfg. Co., Peoria, Ill.

[2] M.S.A.E.—President, Clark Equipment Co., Buchanan, Mich.

the supply of so-called common or unskilled labor becomes scarcer.

G. D. BABCOCK:—We have four Clark tractors in operation in our plant. Obviously, the building of a heavy tonnage, where we designate our product by tons, means the handling of material. We handle the material from machine to machine with elevating platforms and elevating trucks. We use the Clark tractor for all interhauls from division to division and have four working now. We use the Ford tractor with rubber tires to make long fast hauls for considerable distances. We use the Holt 2-ton tractor for long hauls out of the back yard, where we have very heavy cast-steel frames stored in the open. We use the 10-ton tractor for moving cars out of the plant to the siding where switch engines pick them up. Mr. Clark has the only equipment that we have found which fills that one niche; still we find great use for the Ford; we like to see it go, because it makes about 10 m.p.h. and "whoops it up" if it does not have to turn.

A MEMBER:—Do you feel that the future of crawler-type machines lies in the industrial field?

MR. BABCOCK:—Under present economic conditions, yes. If the time should come when large consolidations of land would make the operations more nearly industrial than agricultural, and the land values were high, I believe an opportunity for considerable expansion on the agricultural side would come. I believe that the industrial field offers very great opportunities for the crawler type of tractor.

CHAIRMAN C. M. EASON[3]:—I think it would be a very wholesome thing if tractor engineers had an opportunity to sit down, take stock and study the fundamental economics with regard to food production, particularly as it applies to agricultural tractors in the United States, considering the condition of the agricultural industry as a whole. Such a study would lead to the conclusion that the use of motorized farming-equipment is purely a question of the need of food.

In this Country, we are able now to supply more food than we can eat. Our exports have been seriously curtailed since the war and, consequently, the farmer generally is not in so good a condition as he might be or should be. With respect to food prices, rents, labor prices and other things, the return to the farmer today is considerably lower than the corresponding returns in other industries. If a man can succeed in satisfying the union in Chicago, he can get $21 per day for tacking laths on a wall. Many farmers would be glad to make that much per day by doing work that is much harder and requires more brains and more skill.

We are out of balance in the United States today because we are "overproduced" in wheat and other lines of food products. Their prices are unduly low as compared with other things. For instance, rents in Chicago are from 3 to 10 times what they were before the war. Wages generally are very much higher; the cost of food products is higher than in the pre-war stage. But the return to the farmer is not appreciably higher; it is a little higher in some instances but not so much as in other lines. We in the tractor industry must study the problem of broadening the field of usefulness of the machines and wait until the population reaches a point where it will be pressed for food. The moment it does we must eliminate the horse, because one horse will eat more than two persons in the course of a year; he does not eat the same things, fortunately, but the problem comes down to a question of the number of acres of sunshine per year that is required to produce a certain number of calories of food. It takes about 2.5 acres to keep a human being alive and about 5.0 acres to keep a horse alive. We are probably 10 years ahead on food production. In view of the work of agriculturists, from the standpoints of plant-breeding and of increasing the yield, we could take care of an enormously increased population without straining our resources. Malthus proved about 100 years ago that the world would starve, but we have doubled the population of the world since then and have not starved yet. In the United States we are eating more, per individual, than at any time in the history of the world.

MR. BABCOCK:—I should like to outline a few of the uses that we know of to which caterpillar tractors are put in agriculture. In California, in the orchards and in the berry-growing industry; in Arizona and in the Imperial Valley where it is very hot; in the growing of cotton in those places where it is difficult for animals to exist, we are putting a great many tractors to work. Where the land value is high and intensive farming is indicated, a great many tractors are used.

In what is known as the Mills Orchard in California, where a lemon orchard is located along a very steep hillside, so steep that the trees must be planted in terraces, it is necessary to cultivate in both directions; in other words, the cultivation must be horizontal around the hill and up and down the hill as well; and those checks are 20 to 22 deg. and long enough so that the tractor must move some distance before it drops over the check. It is a rather interesting operation to see the tractor going over these checks day in and day out. It would seem almost impossible otherwise to have utilized a very excellent hillside for the purpose for which they wanted it. There are 1500 acres in operation. Where land values are high and the crop is continuous or repetitive, or the operations must be carried on in places that are difficult yet profitable to operate, we have found a very continuous use for caterpillar tractors.

In the wheatfields of the Northwest and of southern California and the Imperial Valley, tractors are used largely in place of horses for towing harvesters that must work around very sharp pinnacles of hills, so sharp, indeed, that it is impossible to drive up with an automobile at all; if one falls off a harvester at that height, he is likely to roll 150 ft. down the hill before he stops. There is a possibility of using the tractor in those operations, and they are continually finding a greater number of uses for them.

CHAIRMAN EASON:—What is the proportion of the agricultural applications of your product to the industrial?

MR. BABCOCK:—I should say that the industrial applications are about 70 per cent. We have many agricultural operations, but the output of our Peoria plant, which produces heavy-weight tractors, is largely industrial.

D. P. DAVIES[4]:—The product that we build is entirely a round-wheel type, but our sales are just the reverse of those Mr. Babcock states; they are about 98 per cent agricultural and about 2 per cent industrial.

CHAIRMAN EASON:—Where do your machines find their industrial uses?

MR. DAVIES:—We sell some of them in the oil-fields and have sold a number of small tractors equipped with

[3] M.S.A.E.—Assistant to the president, General Motors Corporation, Detroit.

[4] M.S.A.E.—Vice-President in charge of developments of tractors and automobiles, J. I. Case Threshing Machine Co., Racine, Wis.

rubber tires for hauling purposes around industrial plants. We use about eight around our own plant for hauling. We have never pushed the industrial side, although I believe that, if it were pushed, we could sell many more machines.

A. R. SQUYER[5]:—It is interesting to observe the new fields for the industrial use of tractors that are opening up. Some of the uses are undeveloped as yet but are being strongly indicated. They include the clearing of land, the pulling of stumps and the like. In the South, a stump-cutting machine is undergoing development at present so that it can be applied to a tractor for the purpose of mobility. It consists of a large disc operated by the tractor engine; it is placed in front of the tractor, rotates on a horizontal axis and has cutting knives on the face of the disc; when lowered into the ground, the disc advances, "chews up" the stump and scatters it to the four winds. Possibly that sort of apparatus may open up a new field of usefulness for the tractor. The persons that are promoting this thing have a strip of cut-over land 10 miles wide and about 52 miles long that comprises some 250,000 to 300,000 acres.

[5] Research engineer, Holt Mfg. Co., Peoria, Ill.

In mining operations, tractors are used to a limited but increasing extent. In some mines steam shovels are used for scraping when they do not have to go too deep for the ore; when they reach a point where the steam shovel cannot penetrate, that is, the last 5 or 6 ft. before they finally get to the ore, they use tractors. With a combination of a scarifier and a blader, that is, a blader with a scarifier in front, the scarifier rips up the hard stuff and the blader throws it over into the windrow. Then the tractor and the scraper take it out.

QUESTION:—What are the possibilities of exporting American apparatus to foreign fields? Is the foreign competition keen and would any country use this apparatus?

MR. BABCOCK:—We seem to be in so uncertain a state with respect to foreign business that I cannot say that our foreign distribution indicates a trend. We are making some sales.

A MEMBER:—In foreign fields, have the tractors been used mostly in subduing new country, pioneering, road building or clearing up?

MR. BABCOCK:—They are not very active, and no particular trend is indicated as yet.

AMERICAN AUTOMOBILES DOMINATE ASIATIC MARKET

ALTHOUGH the comparatively low purchasing power of the people, poor roads and unsettled conditions in most countries place serious obstacles in the way of rapid developments, the Asiatic automotive market presents attractive potential prospects, recent developments signifying an expansion from a very limited field to a broad one of undefined demand. In other words, the demand for motor products is no longer limited to the small group of foreigners in the seaports but is being extended to the natives of the interior.

Almost from its opening American motor-vehicles have dominated this market. During the late war circumstances favored American companies to such an extent that the market was practically all American. Shipments of passenger cars and trucks to the Asiatic market in the first 9 months of 1924 indicate that this year will greatly surpass 1923 both in number and value. Japan is again the best market in Asia, with British India second and Philippine Islands third. More passenger cars were purchased by Japan, the Philippine Islands and China in the first 9 months of 1924 than for the whole year, 1923.

ESTIMATED MOTOR VEHICLE REGISTRATION IN THE PRINCIPAL COUNTRIES OF ASIA

Country	Passenger Cars	Trucks	Motorcycles
China	8,524	1,150	942
Dutch East Indies	30,629	327	6,137
India	44,445	3,784	15,517
Japan	26,000[a]		4,594
Palestine and Syria	3,013	260	161
Philippine Islands	9,694	2,241	1,501
Straits Settlements	6,064	938	1,542

[a] Includes both passenger cars and trucks.

The accompanying table gives the estimated registration of passenger cars, trucks and motorcycles in the principal countries of Asia, the figures which are made public by the Department of Commerce being as of Sept. 30, 1924.

CITY PLANNING

CITY planning is a regulation by public authority of land, public and private. You think of it generally, probably, as the making of streets, the planning of boulevards, the placing of public buildings and the planning of parks and those public lands; but city planning goes further than that in these days, when we have the power to zone, and deals with the regulation of private lands. The purpose of city planning is the purpose that our forefathers declared was the purpose of government. We have wasted private money in the construction of buildings that became unsuitable in a few years. We have made conditions of life less desirable than they might have been had we been foresighted enough to take thought in time.

Many people have had an interesting place of residence, and near the house came a factory that destroyed its value. Maybe the factory was put where it should have been, and the dwelling should not have been there; or, conversely, the factory may be where it has no business to be. Under our city planning of the future, we can in a large measure prevent this placing of buildings that are appropriate for a certain duty in the wrong place. We must have willing minds to think and plan and always so to act in our public ways about the property in which we are all interested that our conduct shall be in accordance with the rights of those who are to live and work here in the future.—Lawson Purdy, member of New York Regional Plan Committee.

Discussion of Papers at 1924 Semi-Annual Meeting

THE discussion at the Riding-Comfort and the Air-Cleaner Sessions of the Semi-Annual Meeting was constituted of oral discussion offered from the floor and several written discussions that were either read at the meeting or submitted subsequently. In every case copies of the stenographic report have been submitted to the various speakers and the authors for correction and, in the case of the latter, for additional comments. Where these have been received, they have been included in the discussion.

A brief abstract of each paper precedes the discussion for the convenience of those members who wish to refresh their minds as to the points covered without it being necessary for them to refer to the complete text. Those of the members who wish to look over the illustrations that appeared in connection with the papers as originally published, or to read the complete text of these papers, will find all of them printed in the July issue of THE JOURNAL. Publication of the discussion at the 1924 Semi-Annual Meeting is now complete.

AIR-FILTERS

BY L. L. DOLLINGER[1]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

NOISE increases with the wearing of the parts of an engine. Hence, the elimination of wear will decrease the noise and the attendant cost of operation. A great quantity of dust and grit is set in motion by the wind and by the wheels of moving vehicles. The effect of this dust and grit, when it is sucked by the fan through the radiator into the region of the carbureter air-intake, is more severe in the city than in the country for the reason that in the city it consists largely of ground-up pavement, coal dust, sand and gravel and cement that have been scattered about the city by trucks. The quantity of this abrasive material inhaled through the carbureter also increases as the traffic increases, for the dust and grit stirred up by one automobile is drawn in by a following one. Changing the oil in the crankcase, while important, is not sufficient, because the damage to the engine has been done before the oil reaches the crankcase. Even when driven over apparently clean pavements, cars are found to be covered with a layer of dust and grit consisting of highly abrasive material. As air enters the cylinder the finer particles of grit adhere to the oil-film of the cylinder wall and work into the grooves; and soon the fouling and the wearing of parts become apparent. After passing through the cylinder the oil reaches the crankcase, makes the oil supply gritty and produces wearing of the bearings. Loose-fitting piston-rings complicate the lubricating problem, for a heavy oil is necessary, and the heavier the oil the more viscous it becomes at the low temperatures that are prevalent in cold weather.

Steam engines run many hours per day for many years without much wear, but the internal-combustion engine must have the cylinders rebored and requires new piston-rings after a few hundred hours of service. Approximately $100,000,000 is spent annually to replace worn piston-rings and bearings, and more than double this amount is spent for the labor of installing them; worn bearings cause a waste of about 750,000,000 gal. of gasoline annually. Although carbon is usually said to be the cause of leaky valves, a careful study shows that it is not carbon but rather particles of sand and grit, coated with carbon that hold the valves open; carbon itself is soft and extremely fine, like lampblack.

Data recently submitted by E. E. La Schum show that the cost of overhauling an engine is about $550, or about 40 per cent of the cost of overhauling the entire vehicle. As the need of overhauling is caused by wear, this item could be largely reduced by the use of an efficient air-cleaner. Large particles cause trouble but the finer particles will cause infinitely more trouble.

An effective air-filter must have high efficiency, low resistance and durability, should have small size, neat appearance and few moving parts, and should require little attention. According to the returns on a questionnaire recently sent out by the National Automobile Chamber of Commerce, owners of cars specify long life and uninterrupted performance as the qualities most to be desired. Great progress has been made in increasing the durability and life of other parts of cars but the life of the engine has not kept pace. The use of an efficient air-filter would assist in greatly lengthening its life and in materially reducing the cost of operation.

THE DISCUSSION

R. C. DARNELL:—Without doubt, considerable work has been carried on in the last few years, particularly in the last 6 months, on air-cleaners and various devices to enable the engines in passenger cars and trucks to function satisfactorily over a longer period of time and to increase the time between the purchase of the car and its first or subsequent overhauling. There are certain ways of accomplishing this increase in time, or increase in the number of satisfactory operating hours, and apparently the air-cleaner is one of them. Mr. Dollinger has very ably described the functioning and efficiency of one type of these cleaners, namely, the filter type. Any mechanical device possesses advantages and disadvantages. As a result of tests we have carried on, we believe the advantage of the filter type of air-cleaner lies in the fundamental fact that it is not primarily dependent upon the volume of air going through the cleaner, as is the case with many other types. By this is meant that the efficiency is fully as good under light loads and low-speed conditions, at which time the air velocity and volume are slight, and the cleaning efficiency

[1] Engineer, Staynew Filter Corporation, Rochester, N. Y.

is also satisfactory at high speeds and full loads, or under maximum air-volume and velocity conditions. It is our opinion that its disadvantage can be expressed in its tendency to clog. Any device will function satisfactorily for a definite length of time, and one of the many demands on an air-cleaner is increasing that time as much as possible.

We believe that considerable benefit can be obtained by the proper placing of the air-filter type of cleaner. It has been our experience that by installing the cleaner inside of the cab on a truck we reduce the quantity of dirt to be removed to 25 per cent. It is particularly important that the cleaner should not be located where oil vapor or spray can lodge upon the filtering elements. This does not cause a reduction in the cleaning efficiency of the device but rather in the building-up of air restriction because of the combining of oil with dirt in such a way as to eliminate the possibility of vibration shaking the dust from the filtering elements and dropping them out of the bottom of the cleaner. In this connection, we had a rather interesting experience. We were running some tests on pistons and upon completion of a run of 7478 miles, over which time the cleaner was installed, the engine was dismantled. An inspection disclosed 0.018-in. clearance in the top ring-groove, and 0.008-in. clearance in second, with the bottom in its original state.

An analysis of the oil showed 35-per cent dilution. The tests were conducted between the months of April and June of this year, or under normally warm conditions, and it was, therefore, surprising to find a dilution to this extent. The silicon-content of the oil was 3.4 per cent. Separate tests on the cleaner itself disclosed the fact that the cleaner was functioning satisfactorily as a filter.

Unfortunately, however, we had placed the cleaner close to the breather, which gave off an oil spray during a considerable percentage of the operating hours. The oil spray came into contact with the filter and matted the dirt in such a way as to increase the restriction, causing a depression over the filter, which, of course, resulted in high mixture-ratio with a consequent increase in the fuel consumption and the quantity of gasoline that could reasonably be expected to exist in crankcase oil. It is our opinion that, because of high dilution, resulting from the combination of the dirt that came through the breather in which the installation of the flapper valve had been neglected, the air-cleaner under these conditions aggravated the wear conditions of the pistons and the rings rather than relieved or reduced them. In speaking of the breather, here again is an opportunity to do considerable good. A breather of the flapper-valve type which allows the vapor or the crankcase pressure to escape but prevents back-draft in the crankcase will reduce to a considerable extent the amount of dirt found in the crankcase oil. Comparing tests run with and without the flapper-valve type of breather will show conclusively that this is the source of considerable trouble.

R. E. WILSON:—One statement made by Mr. Dollinger was rather contrary to my general impression. I wonder what experimental data he has to support his conclusion that most of the damage by grit is done before the grit gets into the crankcase, in other words, on the way through the engine. It would seem to be contrary to the general experience that, if you change the oil before it accumulates an excessive amount of grit, the wear will be kept fairly low, but if you allow the grit to accumulate in the oil, the wear will increase greatly. In other words, it would seem to indicate that the transference of grit is rapid, just as we found the other day occurs with water and the dilution from the cylinder-wall down to the crankcase and from the crankcase back to the cylinder-wall, and that most of the wear is done in the recirculation of grit hundreds of times over the cylinder wall.

L. L. DOLLINGER:—Before the grit can get into the crankcase, it must pass between the cylinder-wall and the piston, or between the piston-rings and the piston. The greater part of the damage to the most vital part of the engine, so far as efficiency is concerned, has been done before the grit actually gets into the crankcase at the point where you can drain it. It is perfectly true that, because of the circulation of the grit splashing on the cylinder, the longer the engine runs before the oil is changed, the more rapid will be the wear; the condition will be aggravated, but the major part of the damage to the cylinder-wall, the piston and the piston-rings takes place before the grit actually gets into the crankcase.

MR. WILSON:—Does any experimental evidence on that particular point exist?

MR. DOLLINGER:—No, not so far as we are concerned.

V. C. YOUNG:—Some time ago we made some tests with aluminum pistons to check up the wear. We measured the cylinders with a Federal dial-indicator that visibly indicates taper and out-of-roundness. The cylinders showed a taper and out-of-roundness in only one position. We were very much surprised to find that the wear came all on one side. After cutting the blocks up, we found absolutely no wear on the valve side. It actually showed the original tool-marks.

I ran a test with an air-filter and found the wear was reduced between 60 and 65 per cent. This was one of the main reasons I advocated the use of an air-filter on our trucks; the ingoing fuel carried dust and deposited it upon the cylinder-wall and the damage was done at that time rather than after the dust got below and splashed up with the oil.

A. R. SQUYER:—Just before I left the factory, our service-manager stated in connection with this work that, since installing our present air-cleaner on the engine in 1922 (it has been used continuously on our engines ever since), his regrinding department had gone out of business. He has had to regrind but one cylinder since that time. The driver admitted that he had not changed the oil for a period of 4 months, although the engine was equipped with this same air-cleaner.

PROF. A. H. HOFFMAN:—Mr. Darnell referred to the breather. I believe that in the breather is one of the causes of wear that most of us do not think about. In certain tractors, and in one particular make of light automobile, the breather is placed where it can get a considerable quantity of dirt that is thrown up by the front wheels. This is especially the case with a certain tractor when in high-gear. The front wheel, because of its shape of rim throws up much coarse as well as fine dirt.

In the University of California Extension Service, for about 3 years, we have had tractor schools lasting a week. At these schools, the farmers bring in their machines to be overhauled. E. J. Stirniman, who has been in charge of this work, tells me that he has made tests on a great many tractors of a certain make brought to these tractor schools; and that, if they were equipped with a satisfactory air-cleaner, in every case that he has measured up, the rear main-bearing was the loosest, while the front bearing was loosest if no breather-cleaner was used.

It seems to me that points to a possible solution of the matter that Mr. Darnell has mentioned; that there was 3 per cent, I believe he said, of silicon in the dirt that was found in the crankcase oil. What leads me to think so, is that, if I understood him correctly, the wear on the bottom ring was not appreciable.

MR. DARNELL:—That piston had a two-piece ring with the ability to expand upward as well as outward.

PROFESSOR HOFFMAN:—If the dirt had gone from the combustion-chamber past the piston-rings into the crankcase oil, the bottom ring, in all probability, would have worn; so, it seems to me, the silicon that was below came in by way of the breather rather than by way of the carbureter.

MR. DARNELL:—On our car we have now adopted what is known as a "flapper" type of breather. It is nothing more than a little leather washer lying on top of the breather in a cover that goes over the top and is pressed into the housing. Any pressure in the crankcase forces it out but, as soon as the piston rises or a tendency to create a vacuum exists, the flapper lies down over the top of the hole and will not let the air in; consequently, no dirt gets in that way.

In this particular test, the boys had put on an old breather that did not have the flapper. Professor Hoffman is right when he says that the probability is that the dirt got in through the breather and that the breather design should be very carefully looked into. Considerable dirt can get in in that way and do a large amount of damage.

G. C. BROWN:—The remarks that have been made seem to indicate that, in addition to an air-cleaner, the use of an oil-filter is to be considered. If dust gets into the oil and is carried by the oil stream through the engine, wear due to this cause can be prevented by the use of an oil-filter.

The use of a breather-filter also seems to be indicated to prevent the entrance of dust through the breather. It appears that, if the three filters are applied to engines, a material reduction in wear can be made. From the evidence submitted, it seems that dilution is not doing as much damage as was supposed and that dust is the greatest offender.

PROFESSOR HOFFMAN:—May I add a word with regard to filter-type air-cleaners being affected by oil? Certain kinds of filtering material are damaged by oil. Under certain circumstances, some types of filter may be made lower in dust-separating efficiency by the presence of oil; but, as a general proposition, the reverse is true. Generally, an oil-filter is more efficient than a dry filter; however, exceptions to this have been noticed.

CHAIRMAN J. H. HUNT:—Mr. Dollinger has given some figures as to the average wear of the cylinder-wall in cars that, as I happen to know, check well with some figures obtained by other persons. The interesting thing is that he is quoting averages and that his averages check the others. I know that the variations in the amount of wear in cars that do not have air-filters are as great as three to one. It would be interesting if he would give us samples, at least, of those data, showing the range over which this wear extended. I think he said about 0.002 in. in 10,000 miles as the average. Are all cases holding pretty close to that figure, or are some cases as high as 0.006 in. for that length of run?

MR. DOLLINGER:—So far as the wear on the cylinder-wall is concerned, the amount of wear specified in the paper is the average of wear data given to me by engineers who manufacture and operate the cars referred to.

A. L. CLAYDEN:—Has Mr. Dollinger made any microscopic examination of the wear on engines which would tend to indicate the size of the abrasive particles that did most of the damage? It seems to me that a study of enough worn parts in that way might indicate whether it was the larger particles on their first passage that did the most damage or the recirculating in the oil of the finer particles of the nature illustrated in the microphotographs that were shown in another session.

MR. DOLLINGER:—We have not made extensive studies of that particular phase. As stated in the paper, the opinions advanced are the result of observations which indicated that the wear was most excessive in certain localities in California and Oregon where the dust is exceedingly fine and remains suspended in the air at very low wind-velocities. When the sand and grit reaches the crankcase, the coarser particles more readily settle to the bottom of the crankcase and remain there, while the finer particles remain suspended in the oil and are circulated to bearings, cams, gears and other parts of the engine.

RECENT OBSERVATIONS OF AIR-CLEANING DEVICES

BY CHARLES P. GRIMES[2]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

THE author summarizes his experiences and conclusions in chronological order, covering the last 3 years, beginning with the time he first started work with air-cleaners. He gives data on 16,000 cleaners produced in the last 2 years. He sets forth all of his reasons and experiences leading up to the recommendation of a centrifugal cleaner. An interesting suggestion on crankcase construction calls attention to the vicious practice of washing all dust collected in the breather down to the oil-pan with each fresh filling of oil.

[2] M.S.A.E.—Syracuse, N. Y.

THE DISCUSSION

C. P. GRIMES:—Professor Hoffman has made some very practical observations to the effect that a cleaner must be able to operate without attention, must be capable of being installed in a very small and compact space and be tight so that there shall be no possible leak. The device I have described simply screws into an elbow near the carbureter, has the minimum amount of weight, involves the use of no tubing whatsoever and requires the minimum amount of attention.

Much has been said about crankcase-oil dilution and the wear of engines. In this connection I would say that the old reliable two-cycle motorboat engine was lubricated with oil poured into the gasoline tank at the bow of the boat. It gave absolutely satisfactory wear

in operation because the dust particles were not there to abrade the cylinders.

G. W. CRAVENS:—I have used that dust separator on 3, 5, 40 and 60-hp. engines and have found, as Mr. Grimes has stated, that we could pour dust, water or oil into it; apparently all came out and no harm was done. We have not extended the tests over long periods, but in our efforts to find air-cleaners that we could recommend, we tried the centrifugal as well as other types, and this one works very effectively for so simple and little a thing.

R. C. DARNELL:—As a result of some tests conducted about 2 years ago, we came to the conclusion that the rotor did not operate under idling conditions. The tests were conducted in stone quarries, coal yards, and other dusty regions where engines were left idling during the loading. Under these conditions, the truck was frequently entirely enveloped in dust. An inspection of the cleaner under these conditions revealed the fact that the rotor was not revolving. This was true not only on one job, but on all we tested. It was our thought then that at the time when we wished the greatest efficiency, because of excessive amount of dust in the air, we were actually getting the least. I would like to ask Mr. Grimes whether this condition is still prevalent.

MR. GRIMES:—Since this centrifugal cleaner is made to rotate by the flow of air past it, a definite minimum-flow will always be found which will fail to turn the rotor. Our newly adopted louver top and the careful determination of the proper blade-angle have enabled us to cut in half the volume of air formerly needed to rotate the cleaner. A letter just at hand gives me particulars of a test run by one of the largest manufacturers in this Country. A rotor speed of 32 r.p.m. showed a 92-per cent efficiency on 150-mesh dirt particles. I have observed that a leaky connection from the cleaner to the carbureter would prevent a perfect cleaner from turning at idle speed.

The company with which I have been associated during the last 4 years found that the device rotated at a car speed of 3 m.p.h. in high gear on a level pavement. I have felt that 3 m.p.h. on a level pavement was a sufficiently low speed at which to operate the device. You must bear in mind that if you put a restriction on the flow of air through the rotor, regardless of how freely it turns, that will involve a limitation on the high-speed end. This device, with a louver top, turns at a lower speed, however, and is much better than the device with the screen top.

I have observed that the full-load depression on the engine was so many inches of water at the elbow. I took one-tenth of that number of inches, set this cleaner up and made a test. I used the finest dust that I could get; I went to the heat-treating department and took some dust that had come from the air in the heat-treating room from a cyclone separator. It was grayish, very fine and hot, so that it was pretty dry. I put it through the test, with a 97.5-per cent separation at one time and 97 per cent the next time. This convinced me that the dust would separate at low speed just as well as at high speed.

L. L. DOLLINGER:—Does all the dust and grit that gets into the cleaner enter through the top?

MR. GRIMES:—Absolutely, provided, of course, that the cleaner is assembled in free air and allowed to work under normal conditions. If you obstruct the top, the air must enter the bottom, of course, because the engine suction will always find an opening for the entrance of air if one exists. I have made a careful study of the ejection velocity, which ranges from zero with a stationary rotor up to 45 m.p.h. at full load, at which time the rotor is turning about 3000 r.p.m. By disassembling the cleaner I can easily open the fan blades to such an angle that the rotation will drop and the ejection change to injection or an inward flow of air at the bottom of the cleaner.

MR. DOLLINGER:—In making comparative tests of this type of cleaner, I have found a downward current on the inside edge of the shell, but inward from the edge of the shell toward the center of the cleaner the current of air going into the cleaner is very perceptible, more especially at high speed.

MR. GRIMES:—A conflicting statement of this character can be settled only by a careful observation. Mr. Dollinger clearly stated that "This current of air or back-draft was more especially noticeable at high speed."

The whirlpool at Niagara and a wind storm past the end of a fence are similar to the ejection stream of this cleaner in that all three have an adjacent eddy that at certain points is flowing in an opposite direction to the main current. However, the main current is in no case either stopped or reversed. I know that this condition exists and that it is only noticeable after the ejection velocity exceeds 30 m.p.h. The eddy flows in toward the base of the cleaner, and then up, joining the main ejection-stream to come down and repeat. But in no case does it pass up through the body of the cleaner because the pressure there is always positive and trying to get out.

E. F. ANNIS:—Mr. Grimes makes the statement in his paper that to separate 99 per cent of all the dust particles from the air would require an unreasonable expenditure of power at a very high speed. Does Mr. Grimes intend to make the statement that the centrifugal or inertia type of cleaner will separate 99 per cent of the dust particles from the air?

MR. GRIMES:—A powerful electric motor rotating at very high speed could easily remove 99 per cent of all the dust particles from all of the air acted upon by the cleaner. The self-ejecting centrifugal air-cleaner simply centrifuges all of the dust particles into the outer zone or outer one-quarter volume of all the air entering the top of the cleaner and then automatically ejects this dirty outer-zone or one-quarter volume with its load of dust without having to accomplish the enormous task of absolutely separating each speck of dust from its adjacent envelope of air.

MR. ANNIS:—What is meant by the cleaner's acting as a flywheel to the carbureter air-stream?

MR. GRIMES:—All four-cylinder and many six-cylinder engines have a very definite surge or pulsation to the air-flow at the carbureter entrance, when operating under full throttle at extremely low engine-speeds. Air flowing past the fan of an air-cleaner will make it rotate. Should the fan itself be rotated by any means at all, it will cause air to flow past it. One passage of the air over the carbureter jet will extract the proper amount of fuel. Should the air surge past the jet three times instead of once, the mixture will be too rich for either power or economy. The rotor of the cleaner has weight and inertia. It runs at a uniform speed and will push or pull as needed to smooth-out the air-flow.

MR. ANNIS:—Does Mr. Grimes mean to say that his air-cleaner will increase the power of the engine by from 1 to 8 per cent, as stated in Table 2?

MR. GRIMES:—If the carbureter air-stream is free of pulsations at low speed and full throttle, the centrifugal air-cleaner will not be able to smooth-out this air-flow and therefore for this same reason it will not be able

to perform a service that has always resulted in an increase of power and economy. Table 2 is a fair example of many similar tests. I make no claims for increased power but have a record of tests data that in the majority of cases does show an increase of power and economy.

MR. DOLLINGER:—What were the results of Professor Hoffman's efficiency tests on the United air-cleaner?

MR. GRIMES:—Professor Hoffman has stated that he has not tested our air-cleaner for the last 2 years. For that reason he did not feel that he would be justified in giving the determinations that he made over 2 years ago, as the standard of efficiency of our present product. We have taken up with Professor Hoffman the question of making a rather extensive test of our air-cleaner, using the exceedingly fine dust that he has been able to obtain in California. The report of this test will be available in the near future.

America's largest motorcoach manufacturer told me that two of his bus engines were a total wreck after running 2 weeks without a cleaner. Two new engines on the same route have been running for months with the centrifugal cleaner attached and seem to be in perfect shape.

At El Paso, Tex., the automobile dealers held a 2000-mile endurance run. At the end of this run a car with the centrifugal cleaner attached to its engine showed less than 0.0005-in. total wear. The engines of competing cars without cleaners were completely worn-out; they would not run idle at less than 1000 r.p.m.

A prominent truck manufacturer told me that a crankcase sludge consisted of

	Per Cent
Silicon	10
Iron Oxide	37
Carbon	45

This engineer recognized at once that one grinding-wheel might easily grind away 100 times its weight of iron. The 37 per cent of iron oxide could have remained on the walls if the 10 per cent of silicon could have been kept out of the engine. Compare the life of a steam-engine cylinder with that of a truck engine and draw your own conclusions.

AUTOMOBILE RIDING-COMFORT

BY S. P. HESS[a]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

RIDING-COMFORT is defined as the transportation of an automobile passenger in so easy a manner that the trip will be a pleasure and not a hardship. Since spring-suspension constitutes the basis of riding-comfort in passenger cars, the paper deals with some of the important factors that determine correct chassis spring-suspension. An analysis made by the National Automobile Chamber of Commerce of replies received to a questionnaire it circulated among 20,000 car-owners is presented in proof of the genuine interest the motoring public has in the riding-quality of a car, and the variable factors that have an influence on spring-suspension are stated to be the type of spring used, its physical dimensions, the amounts of sprung and unsprung weight, frame construction, wheelbase dimension and the kind of material used.

Horizontal, vertical and sidewise motions of a car are analyzed, and a periodicity chart is shown for passenger cars of from 112 to 116-in. wheelbase. Since periodicity is a function of deflection, the derivation of the number of vibrations per minute is explained and the reduction of vertical motion is discussed.

A periodicity machine designed to determine the value of inter-leaf friction as a damping medium is illustrated and described, and the results obtained from tests are stated. Sidewise motion and the effects of balloon tires and four-wheel brakes on riding-quality are treated briefly.

THE DISCUSSION

PRESIDENT H. M. CRANE:—The succeeding sessions will be directed toward lengthening the life of the power-plant and the other parts of the car. The present session has to do with lengthening the life of the passengers. I am aware of no subject connected with motor cars that seems more capable of infinite and indefinite discussion than that of riding-comfort, the reason being that no two people ever want to use an automobile in the same way. Some want to drive fast and some to drive slow. Some always ride in the front seat and some want to ride in the rear seat. But out of all the differences of opinion, undoubtedly has been developed a valuable source of knowledge of certain features of a car that contribute, apparently, to the satisfaction of the greatest number of owners. One serious trouble is that we have no satisfactory yardstick with which to measure riding-comfort; at least, if we have one, I do not know of it. This meeting was designed originally with the idea that we might be able to bring out something in the form of proposals that would lead to arranging methods of measurement which would take the place of the old system of riding in the car and getting a man's personal judgment as to the result.

Recently, I had a very unpleasant illustration of just how hard it is to estimate riding-comfort. I had a badly inflamed tooth and had to ride about 25 miles in a car that I know as well as I know anything. I had ridden day after day in it for about 18 months. On that particular day, because of the pain, that car seemed to me to ride like an awful truck; and yet, after the tooth had been pulled and physical conditions returned to normal, riding in the car seemed all right. I have no idea that the car changed in the meantime. I am sure it did not change, but my judgment was badly warped on that particular day.

I hope and believe that this session will be a starting-point from which several sessions will result because, in the long run, this is a very important question. It is perfectly true that many of our roads are becoming better and better and that we have many more miles of good road, but that simply means more possible mileage for motor cars. I think the mileage of unimproved roads used by motor cars will not be reduced very much for a long time.

First thought may incline us to believe that, because it is so short, Mr. Hess's paper does not present much information. But it contains the concentrated data ob-

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tained from many years of actual experience of putting springs on automobiles. However, I disagree with some features and one is the front-spring period that apparently is allowed. I will admit that, if a car must be sprung without any extra damping-devices, it may be necessary to use front springs of as high a period and as stiff as shown on Mr. Hess's chart; but, in fact, a very much better-riding car will be obtained if the front springs have a period as low as 100, always provided that some form of rebound-check or something of that kind is used to prevent excessive plunging of the car under certain conditions. Interleaf friction undoubtedly is a very important part of the leaf spring; in fact, no obvious reason for using a leaf spring exists if one does not want to utilize interleaf friction. My experience with recent production cost is that, to save cost, the interleaf friction is not treated so seriously as it might be.

In the horse-drawn carriage days, when Brewster wished to make his carriages ride in the way they did ride, a way that created a very great reputation, each spring-leaf was individually fitted to its adjacent spring-leaves by grinding in such a way that a large smooth bearing-surface was obtained, as well as the closest approximations to friction of rest and to friction of motion. But many modern springs, especially those in which the leaves are not tapered, produce highly concentrated stresses in a few spots and a tendency to dig-in between the leaves that is bound to produce a jerky-riding spring; that is, the leaves are so stiff when they are at rest they have to tear themselves loose before they can really bend at all; they are continually locking and unlocking, and, until such a spring has run many thousands of miles and run-off the high spots, one will never get a first-class ride. It is very surprising what an effect that has, even with pretty good springs.

About 10 years ago we had a car of rather short wheelbase, having no shock-absorbing devices; it was entirely dependent on its springs. It was a very high-speed car. When we first took it out, none of us had nerve enough to drive it much over 55 or 60 m.p.h. The car took on a peculiar floating motion that all who have driven cars probably have experienced. It seemed actually to rise away from the road, and one began to feel that it was going off the road entirely. The owner took it abroad and brought it back after driving about 8000 miles in 3 months. When we had occasion to drive it again, absolutely none of that effect was left in it. The smoothing-in of the leaves together, and probably a certain amount of rusting in the leaves, resulted practically in a damping-effect such that the car, instead of appearing to rise when driven fast, appeared to squat, the latter effect being the way in which a car that rides well at high speed can be recognized. It is just such little things that, when we are getting down to details, will have to be given much more consideration than they have been in the past.

One thing in the paper that impressed me is the noticeably great difference in the weight of the springs that were compared for period of vibration. I wonder what would be found in a spring when an attempt is made to obtain increased friction by having more leaves, with the total weight of the spring the same. So far as I have been able to see, the leaves being thinner, more surfaces are in contact but there is less actual leverage in each surface and the result is about the same. To get the increased friction, it is necessary to add weight to the spring, and weight added to the spring means more cost unless the effect can be obtained by using much cheaper material.

WALTER C. KEYS[4]:—Mr. Hess says that each car requires separate study as to its spring-suspension. I say that each body model for each car requires such separate study. I know of a case in which a complete line of cars had good riding-quality, except one body-type. Somehow, one job went through and was overlooked.

Commenting on the utility of a leaf spring, it is a very good thing. First, it is a yielding member connecting the axle and the frame and, second, in most cases it serves as a radius-rod on the front wheels and also as a cross radius-rod capable of taking side sway. All are familiar with the effect of driving a car through frozen ruts, when the car is thrown from side to side. I think that the leaf spring will be a permanent part of the motor car.

T. J. LITLE, JR.[5]:—I prefer using many spring-leaves and using tapered leaves with rounded ends, because, after very careful analysis and careful research conducted to determine these things, we found this practice would give the best ride. If one is trying to build a good car and is not worrying much about expense, I think that is the direction in which to proceed. We should not be satisfied simply with putting a spring on a car and testing its riding-quality by riding in it. We should make some serious attempt to measure the riding-quality by devices designed particularly for that purpose. A great amount of work has been done along that line in this last year.

The use of many spring-leaves certainly affords a better ride. In the case of the front spring, this is decidedly noticeable. For instance, where 14 leaves are used as compared with 9 leaves, a very marked difference in the riding-quality is evident. I think that we not only obtain increased interleaf friction, but that we gain increased insulation to shock; it certainly means that less shock results if it is transmitted through the many breaks and oil-films between the leaves. It also is sensible to provide different kinds of spring for different kinds of body or to divide the line of bodies into several classes so that three to five different kinds of spring will be available to carry different weights of body. If that is not done, it is too much of a compromise.

S. P. HESS:—Referring to Mr. Crane's remarks concerning the difference in weight of the springs tested and compared for period of vibration, consider the 7-leaf and the 14-leaf front-springs, weighing 28.0 lb. and 39.8 lb. respectively. Compared to the superposed weight of 400 lb., the difference of 11.8 lb. in weight is almost negligible. Again, the 7-leaf spring has a flexibility of 427 lb. per in., whereas the 14-leaf spring has a flexibility of 455 lb. per in., which, ignoring interleaf friction, should give a lower period in favor of the 427-lb. spring. Such was not the case, as shown by the results. This is another indication of the decided influence of interleaf friction and the fact that the slight difference in weight can be neglected. A similar argument may apply to the rear springs tested.

PRESIDENT CRANE:—Regarding the relative weights of the springs compared, I did not mean my previous statement to have anything to do with the periodicity of the two. What I did mean is that comparing a 40-lb. spring with a 56-lb. spring having a different number of leaves, is not comparing similar things. The weight of metal in one is much more than in the other, but the damping is accomplished by the increased weight of

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[5] M.S.A.E.—Chief engineer, Lincoln Division, Ford Motor Co., Detroit.

metal, and I am not satisfied that the difference in damping is very great if the same weight of metal is disposed in a greater number of leaves. In adding leaves to a spring that is already strong enough, thus going beyond the original weight and increasing the thickness, we know perfectly well that the resulting increase in interleaf friction is very noticeable. I think that the cantilever spring, because it is short and thick and has very many leaves, tends to have a higher interleaf friction than does a long semi-elliptic spring.

OTTO M. BURKHARDT[6]:—Speaking of interleaf friction, I think that spring-makers should interest themselves somewhat in the subject. So far, I have found them neither interested nor posted in this regard. When we buy springs, we should specify a certain period and, in specifying the period, we should have a definite knowledge as to what extent this period is influenced by the interleaf friction. Although the amplitude of the period is stated in Mr. Hess's paper, the paper does not contain an analysis of this amplitude. It would be highly interesting to have such an analysis so as to derive just what influence interleaf friction has on the period, because it is the period that is important. Mr. Litle said that high interleaf friction is an advantage because it has a tendency to reduce the shocks or prevent them from reaching the vehicle, but I believe that if friction is present and if it is undesirable in the extreme, it is also undesirable if carried part way. The spring having much interleaf friction will be nearer to being a solid beam. So, a multiple-leaf spring has wonderful advantages, but it loses these advantages if it has high interleaf friction.

GORDON R. PENNINGTON[7]:—Two problems are involved. One is the absorption of direct shocks. The other is the absorption of rebound or oscillation energy. These two problems are distinct and should be considered independently.

As for direct shocks, the softer the spring is, the less force and acceleration will be transmitted to the chassis frame and, therefore, to the passengers. This is simple physics. Therefore, the softest spring will yield the greatest relief from direct shocks. In actual practice, spring flexibility is limited to an amount just sufficient to prevent the axle from striking the frame under the most severe combination of road irregularities and speed for which the particular car is designed. The greater the permissible spring deflection is, the softer the springs may be. Likewise, if a bumper is used, a rubber pad, a jack spring, or a true shock-absorber of the hydraulic type, more flexible springs can be used safely. Thus, for the absorption of direct shocks, the ideal suspension is one with the maximum deflection-range, along with an effective bumper, so that springs of the minimum stiffness can be used. Such springs necessarily will have low inter-leaf-friction and will not absorb rebound energy satisfactorily. If an attempt is made to increase the inter-leaf friction, this will be at the expense of spring flexibility and, therefore, of riding-comfort. Consequently, auxiliary devices must be depended upon for absorbing rebound energy. We should provide the maximum spring-flexibility for the absorption of direct shocks and separate spring-damping devices for the absorption of rebound energy.

MR. HESS:—I think we have two subjects confused. In the first place, periodicity is a function of deflection. We must obtain a certain deflection on the front spring for say 140 periods, and we must obtain a greater deflection on the rear spring for 70 periods. It is not a question of whether the spring is light or heavy in flexibility, provided it carries a certain corresponding load for a fixed or chosen deflection. In other words, a light car would have a light load on the rear spring corresponding to a deflection for a given periodicity, and in this case the flexibility would be low. On a heavy car, the load would be greater; the travel or the deflection would be the same for a given periodicity, but the flexibilities would be correspondingly greater. In my opinion, damping has nothing to do with periodicity, except to slow-up its intensity; it starts at a certain period and continues at this period until it finally dies out. The period is there, but the intensity of the period is different; that is why we put on various kinds of damping devices. I do not want to say that you can spring a heavy car and get a satisfactory ride, the best ride possible, by using springs alone. On the other hand, if damping devices are not used, considerable improvement is obtained by utilizing inter-leaf friction.

FRANK C. MOCK[8]:—The engineer's view of a given subject must depend somewhat upon the result he is trying to achieve. The executive engineer, deciding what spring-suspension to use on his next year's model, must take a general view of the requirements and make the best compromise he can with the means available. The research engineer working on this subject should analyze it completely, and must particularly avoid generalities in thought. I want to emphasize what Mr. Pennington has just stated; that is, that we are confusing matters when we say that internal spring-friction is necessary to secure good riding-qualities.

I became rather sceptical as to the advantages of internal spring-friction through the following experience: I had a car that rode about as badly as any I have ever known and, upon measurement, found that its front springs had 1¼-in. initial deflection, with leaves that were pretty badly rusted, thus giving 100 lb. internal friction; that is, it required a strain of 100 lb., in addition to the weight resting on them, to cause the springs to begin to deflect. The tires were of standard type and had ⅜ to ⅝-in. initial deflection with the air pressure used. I then substituted springs having a 2⅛-in. initial deflection and a 50 to 60-lb. internal-friction, which I think is about that ordinarily found. This change substantially amounted to doubling the flexibility of the springs and made the car ride somewhat better, but I still could feel the cobblestones, the small depressions in a brick pavement and particularly the raised joints in a concrete road. I then had the spring leaves of both the front and the rear springs polished, buffed bright and lubricated with graphite grease, so that the internal friction could scarcely be measured on our scales. The result was that the car had an entirely different feeling. The small inequalities in the road surface could scarcely be detected and the action of the car had a certain restful feeling that I had never experienced before, though I have since equalled it with flexible springs and balloon tires. The reaction motion of the springs, however, was very evident and, at certain times, very objectionable. Nevertheless, I would very much rather have the low-friction springs with properly controlled rebound than springs with internal friction in them.

Since I have been measuring springs and paying particular attention to their action, I have found that the friction changes the period of oscillation so much that

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[7] M.S.A.E.—Manager, truck equipment department, Van Dorn Iron Works Co., Cleveland.

[8] M.S.A.E.—Research engineer, Stromberg Motor Devices Co., Chicago.

the formula which Mr. Hess gave cannot be applied safely. High friction in a spring lowers the rate of oscillation, making the spring act more slowly; which would indicate a greater flexibility if the degree of friction were not known. Actually, the spring with the high degree of internal friction is much less flexible and much harder-riding. Also the actual value of the friction seems to be almost constant through a wide range of spring action, and application of this consideration to the formula that Mr. Hess gives will show that, for a given spring and load, the oscillation will be slower at small amplitudes than large amplitudes, because the friction is a larger percentage of the force of restitution at small amplitudes.

The more one reads the current literature on spring-suspension, the more evident it becomes that we have omitted the necessary basic analysis of the subject. Part of the riding discomfort comes from the displacement of the body and the passenger by road inequalities, and part of it comes from the reaction of the springs. A more flexible spring gives less of the first displacement and more of the second. A constant application of friction, either internal or external, to the spring action will increase the discomfort from the first cause and decrease that from the second. The more flexible the spring used is, the greater the need is for proper friction application. It seems very evident that friction should be applied at some times and not at other times, and that we can expect to make our cars materially more comfortable only by the proper development of both spring flexibility and properly regulated absorption of the spring reaction.

DR. H. C. DICKINSON[9]:—I have been interested for a long time in just the thing that Mr. Mock has suggested, namely, that it would be a good idea to try to find out something more about the underlying reasons for the various difficulties that we meet in determining this matter of riding-quality. A number of years ago, I had a car that had been driven for some time and was originally a very easy-riding car. I thought that the conditions of the springs might have something to do with the fact that it was not riding as easily as it once did; therefore, I took all the springs off, ground the surfaces of all the leaves, put them together and lubricated them well. This had exactly the effect that Mr. Mock has suggested; the riding-quality of the car was improved distinctly.

I have been puzzled for some time as to exactly what happens to cause the friction in a leaf spring to affect the riding-quality of a car as it seems to do. The friction does not affect the period appreciably. It affects the amplitude in that it makes the vibration which has started damp out in a shorter time and therefore produces a less number of vibrations. What is there in the sensitiveness of the human mechanism that responds to something other than the normal period and amplitude of the springs? All have noticed that, when riding over a stretch of asphalt pavement, fairly easy-riding properties are experienced and that when riding over a stretch of almost perfect concrete a distinct difference in the riding-quality of the average car is noticed. Those pavements are very much alike except for the fact that, usually, excessively small waves exist in the concrete that do not appear in the asphalt. That raises the question: To what sort of motion is the human system sensitive?

Recently a small vibrating machine was devised in the Bureau of Standards, the idea being to survey what people could feel in the way of motion. We designed this machine with a vibrating platform that had an amplitude up to 0.03 or 0.04 in. and a period of from 200 or 300 to 2000 or 3000 vibrations per min. We found that an amplitude of something like 0.001 in. at a period of vibration of something like 500 per min. is distinctly disagreeable; it is not only disagreeable when one sits on the platform and puts one's hand on it, but it also is disagreeable when an automobile cushion is put on the platform and a person sits on that. In other words, the human mechanism is sensitive to vibrations of as small an amplitude as 0.001 in. That is a very small range of motion, and not much effort is needed to transmit an effective vibration of 0.001 in. to the body of a car. When using a spring that has inter-leaf friction, and particularly if the inter-leaf friction happens to be of the kind that Mr. Crane suggests, in which the irregularities of one leaf drop into another, that inter-leaf friction is of the same nature of performance as that obtained when a violin string is vibrated by a bow; it is not smooth, but has irregularities and is capable of producing small forces that can be transmitted to the body of the car. It is very likely that the human mechanism is sensitive to those things to a degree that has not been appreciated as yet. It startled me to find a sensitivity of anything like the degree stated. I believe the subject might well be one for research.

MR. HESS:—I believe that, if a car is equipped with a damping device of some kind in conjunction with leaf springs, a lubricated spring is all right. My statement about inter-leaf friction applied to cars not equipped with any form of damping device. We take advantage of the friction to serve as a damping device in itself.

PRESIDENT CRANE:—In this matter we cannot overlook the fact that we have a very complicated situation, because the springs are interposed between the axle and the weight of the body, and between the same axle and the more or less rigid road surfaces, another set of springs is interposed, the tires. The latter set of springs is of a very high degree of resiliency, and tires are being made more and more resilient all the time. The former fabric-tire was not very resilient; neither is the present truck tire. But the later cord-tires and balloon-tires are probably very close to being 100-per cent resilient. If that resiliency is coupled with a spring above the axle, between the axle and the body, a spring that is also 100-per cent resilient, and damping is not provided, the result is bound to be some very weird and excessive periods produced in the intervening weight. Many cars have intervening weights that run from 250 up to 700 lb. and such weight is being tossed back and forth. It must be damped somewhere, either by inter-leaf friction in the leaf-spring or by something else. If it is not damped, there will be occasions when those forces, coming together in cases where the pressure in the tire just suits the spring load above it and the particular form of road surface, will carry that weight clear off the ground, and the distance it will go is sometimes astounding. For this reason, there must be damping, but it is equally uncertain whether damping should be put in the spring itself or more effectively in some exterior device that can accomplish it better and more cheaply. That is a matter we ought to determine.

MR. LITLE:—When I said that I preferred many leaves in a spring, I did not mean that the inter-leaf friction should be increased. I mentioned the fact that an oil-film should be interposed between each leaf and that I think the many oil-films take up some of the shock that Dr. Dickinson mentions. Also, that if the spring is

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lubricated (and it should be lubricated), some auxiliary means for restraining its action, for preventing rebound, should be employed. My experience is that a device should be applied to restrain this rebound after a certain amount of deflection has taken place; that no restraint whatever should be imposed upon a spring up to a given point. To that point, it should be allowed to operate freely. In my estimation there should be a neutral zone in any device that is installed. I do not believe in using any shock-absorbers on good roads or on city streets, but I do believe in using them on rough country roads. Therefore, they should be brought into action automatically, in that way.

L. B. KIMBALL[10]:—The value of interleaf friction depends upon the type of irregularities in the road over which we have to ride. In concrete roads where the bumps are of very small magnitude, a well-lubricated spring transmits less of the axle movement to the sprung mass of the car than one having friction between the leaves. This was ascertained by actual measurement with the riding-quality indicator. However, in traversing a series of bumps that happen to coincide with the period of the rear suspension of the car, if no restraining factor is provided, the sprung mass may reach an acceleration of over 32 ft. per sec. per sec., in which case the occupants would be thrown upward. Therefore, the restraining factor should be a compromise that will maintain as much of the spring freedom and riding-comfort as possible under ordinary conditions and yet keep the car from violent oscillation under bad conditions. Some of the shock-absorber manufacturers have made shock-absorbers that allow the spring perfect freedom over a limited range, beyond which the restraining force is proportional to the distance. Some of the easiest-riding cars that were tested used inter-leaf friction, the springs being made up of a large number of thin leaves. The results obtained by slight changes in spring design brought about an improvement in the riding-quality which far surpassed our expectations.

F. P. HERMAN[11]:—Regarding spring friction, we have been doing a considerable amount of experimental work during the past 2 years that has developed some rather surprising results. Our experiments have been conducted in an endeavor to answer some of the questions raised by Mr. Burkhardt. Where the spring resistance on a new spring comprised 10 to 15 per cent friction resistance, we have found this friction increased to 20, 30 or even 35 per cent after the car had been used 6 to 12 months in ordinary service. This increase is due entirely to rust and the accumulation of grit and dirt between the spring leaves; naturally, a decided change was noticed in the riding-quality of the car, due to this stiffening of the spring. On the same car, by lubricating and covering one of the other springs, the same amount of friction resistance was retained during the test extending over 12 months. For this lubrication a special compound of a sticky nature was used, and no loss of lubricant occurred during the test. These experiments confirm our opinion that, when springs are properly covered and lubricated, their original condition can be maintained during the life of the car.

JOSEPH A. ANGLADA[12]:—We recall the Brush runabout and the Lansden ambulances that were suspended on helical springs. In those days, when they used shock-absorbers having a natural period within a limited range of spring deflection and when they adjusted those shock-absorbers properly, those vehicles seemed to ride pretty well, particularly at speeds of 20 m.p.h. or less. Therefore, might it not be advisable to consider the use of helical springs, which have no inter-surface friction, and shock-absorbers for dampers, as a means of studying the fundamentals of car suspension? These would provide a means for separating the effect of spring-material deflection from the effect of friction very definitely, and would permit adjustable combinations of the two factors.

PRESIDENT CRANE:—Regarding Dr. Dickinson's remarks about his test, I emphasize the great importance of that feature of the work. It is a real trouble. We do not know exactly what there is in the riding of certain types of car that is irritating to certain people. We know perfectly well that some people are not irritated by certain types of riding; a physical limitation undoubtedly. We built a car for years that had a rolling motion much like that of a ship. Many of our car-owners were enthusiastic about the riding-quality, but every now and then an old person, or frequently a child, would be seriously upset when riding in the rear seat by that simulation of a boat at sea; it would make them actually feel nauseated. The thing that will be interesting is whether this is a period of so many vibrations per second or whether it is an acceleration.

We know that, if it were done slowly enough and the person did not see the process, a chair in which that person is seated can be lifted off the floor several feet and replaced on the floor, without his knowing that he has been moved. As the speed with which such a movement is made increases, it becomes more and more uncomfortable. We do not know just what the effect is. There is the big vibration, the long rolling-swell effect; then there are the smaller vibrations produced by cobblestones, and even by roads like the asphalt road that is slightly rippled, or by the concrete road. There are not only vertical but also horizontal vibrations. Almost all spring-suspensions tend to a production of a high-period lateral-vibration that becomes uncomfortable to many people. These are all things that we know nothing about as yet; we sort of guess at them and feel our way. In the future, the public will demand, and rightly so, that we do much more about all this than we have done in the past. If we assimilate the low-pressure-air tire rapidly, we will avoid many of the worst features. That is an all-round cushion, a wonderful vertical cushion and, at present, it is too good a horizontal cushion laterally to suit some of our car-builders; it produces shimmy and weaving and various things like that. That ought to tend to make a good riding job in other ways.

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A RIDING-QUALITY INDICATOR

BY E. H. LOCKWOOD[13] AND L. B. KIMBALL[14]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

A PORTABLE instrument of the seismograph type has been designed for measuring the riding-quality of vehicles. Readings are made by a continuously revolving counter that automatically sums up the vertical displacements of a partly suspended weight. As the counter readings are a measure of the riding-quality, a large reading indicates poor riding and, conversely, a small reading indicates good riding. An arbitrary scale graduated into revolutions of the counter per mile of travel translates the readings into riding-quality; a reading of 10 indicates "very smooth," 20, "good," etc. The instruments have been calibrated in a special testing-machine in which the readings can be observed under an harmonic motion of fixed period and amplitude.

Comparison of the riding-quality of balloon tires and of cord tires, made on three different automobiles run over a variety of roads, shows results that are very favorable to balloon tires. Data on the effect of shock-absorbers and of car speed on riding-quality are now being obtained. Detailed records of the riding-quality of an airplane, as measured by the integrating instrument, show the airplane to be slightly better than the best automobile.

THE DISCUSSION

PRESIDENT H. M. CRANE:—I think Professor Lockwood would be the first to say that he is not exactly sure yet what the quantitative meaning of any of these results is, but they very plainly do have a qualitative meaning. It is highly probable that, by variations in the instrument and methods of use, some very interesting comparisons can be made between certain features of the car. This reminds me of something we did about 5 years ago. We had finished a chassis and had no body for it. We placed an ordinary cross-seat for the driver in front. Behind it we had a large wooden box that was fairly springy, mounted on 2 x 4-in. joists on the frame. This did not weigh the chassis down enough, so we put a large concrete block that weighed 400 or 500 lb. into the box. The block stood up above the surface of the box and, when more than two people were riding, one or two would sit on this concrete block. I commented upon it as giving the best riding I ever experienced. When sitting on that concrete block, I could feel no vibration. The reason was that, due to the springiness of the box and the great weight, no very fine vibrations came through it. If the concrete block had been replaced by the softest possible cushion, the riding-quality would not have been nearly so good. However, I do not recommend a 500-lb. concrete-block to take the place of a rear cushion.

PROF. EDWARD P. WARNER[15]:—In order that this meeting might include a discussion of as many forms of test as possible, Prof. William G. Brown, of the Massachusetts Institute of Technology, and I have done some recent work using the old and familiar method previously employed by Mr. Keys, Professor Lay, Louis Coatalen, Mr. Aston and others, of mounting electric lights on the body, the axle and other parts of a car, as well as on the persons of the passengers, and running the car past a camera so that each light traces a more or less irregular line that indicates the motion of the several parts. From these records, the amplitude of the motion and its period can be calculated. In the particular experiments that we performed, we had lights mounted in most cases on the rear axle; on the body over the axle or, in one case, somewhat forward of the rear axle; on the radiator cap; and on the shoulder of a passenger in the rear seat.

Of the two cars used, Car *A* was a Ford sedan having auxiliary springs of helical type at the front, and no shock-absorbing device. Car *B* was a 1924 Buick roadster without snubbers or shock-absorbers.

The five curves of Fig. 1 show a series of records that we made with Car *B*, when running it over a single obstruction laid on the ground, the obstacle being a plank 3 in. thick and about 3 in. wide on top and beveled 45 deg. on the edges. We ran Car *B* over it at various speeds. The surface upon which the plank was laid was a concrete platform as near to absolute smoothness as anything we could get. The run is from left to right and the dotted curves represent the axle, the light which was mounted on the brake-drum being interrupted by the passage of the spokes. The body curves are solid lines, most of them being roughly at the same level as the axle curve corresponding to the next lower speed. The light on the body, in this case, was about one-third of the way forward from the rear to the front axle. We put all the lights on one film. The dots at x_1, x_2, etc., show the position of the center of the plank. The speeds were all very low. We did not have enough room on this smooth surface to get the car up to good speed.

We started at a speed of 1.7 m.p.h., to eliminate bouncing as much as possible and map the contour of the plank with the tire continuously in contact. As is evident from Fig. 1, the axle curve is symmetrical about the center line of plank, while No. 1, the body curve, has a wave at *a* which occurred when the front axle passed over the bump. Another set of waves, made when the rear axle struck, is shown at *b*. A distinct oscillation of the body is evident, even at that slow speed, the depression of the body below its normal line on the rebound being nearly half the rise in the first oscillation, and the second oscillation being barely perceptible. Curve 2, taken at 2.7 m.p.h., shows a very marked second oscillation of the body, and Curve 3, at 4.7 m.p.h., indicates a distinct second bounce of the axle. Curve 4, at 7.0 m.p.h., shows more, and Curve 5, at 10.5 m.p.h., even more. Curve 4 is perhaps better than Curve 5. At the 7-mile speed, which shows the bouncing a little better than the 10-mile run does because the curve is more contracted, several bounces of the axle are evident. Six can be seen easily, and four of them were of considerable magnitude, although the car was running over a smooth surface.

At the point *c*, on Curve 4, the axle goes down 1¼ in. nearer to the ground than it is when the car is running steadily over the smooth surface. Presumably, that represents the compression of the tire, which was 4½ in. in diameter and inflated to a pressure of 45 lb. per sq. in. That compression gives enough accelerating force to

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[14] Laboratory assistant in mechanical engineering, Yale University, New Haven, Conn.

[15] M.S.A.E.—Associate professor of aeronautical engineering, Massachusetts Institute of Technology, Cambridge, Mass.

throw the axle up against the compression of the spring, and so on through a succession of cycles that increase in number with an increasing speed. Unfortunately, the motion of the body cannot be seen very well because the curves do not extend far enough, but it is evident that the damping is rather light. The body goes through two full oscillations at *d* on Curve 2, at a speed of only 2.5 m.p.h., and the number is increasing as the speed increases.

One interesting point about passing over the plank, which has sharp edges on the top, is that the peak of the axle motion rises to an almost constant distance above the datum line that represents steady travel over a smooth surface. The distance as measured on these charts lies between 2⅞ and 3½ in., but the position of that maximum shifts to the right. At the very low

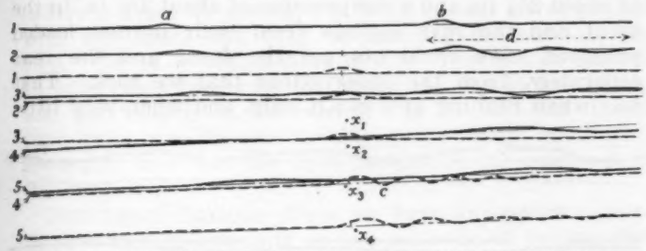

FIG. 1—SERIES OF RECORDS OBTAINED WHEN A 1924 BUICK ROADSTER WITHOUT SNUBBERS OR SHOCK-ABSORBERS WAS RUN OVER AN OBSTACLE

The Solid Curves Are Those of the Body Movement and the Dotted Ones Represent the Axle Movement. It Should Be Noticed That the Body Movement at Any Speed Is Approximately the Same as the Axle Movement at the Next Lower Speed. The Position of the Center of the Obstacle, Which Was a 3-In. Plank, with a 45-Deg. Bevel at Each Edge and Measuring Approximately 3 In. on Top, Is Indicated by the Dots x_1, x_2 x_3 and x_4. The Speeds Corresponding to the Various Sets of Curves Are Given in the Accompanying Table

Curve	1	2	3	4	5
Speed, m.p.h.	1.7	2.7	4.7	7.0	10.5

speed, the axle has its maximum rise right over the center of the plank. At 10 m.p.h., the axle gets its rise considerably beyond the center of the plank; that is, the tire that left the ground jumps off the far side of the plank and considerable tire indention has taken place in the earlier stage of the motion because, although the plank was 3 in. thick, the axle had risen only about 2⅛ in. when it passed over the center.

The maximum depression of the axle below the normal running position, at these low speeds, is 1¼ in. Incidentally, if we treat the curve of axle travel as a damped harmonic motion, to which it probably approximates pretty closely, we find that, at a speed of 10 m.p.h., the maximum vertical acceleration of the axle is only three times the acceleration of gravity, or 97 ft. per sec. per sec.

In a paper[16] presented to the Society a few years ago, it was suggested, as the result of calculation, that the value of the vertical acceleration might become very much higher than that. A value of something like 100 *g* was mentioned as possible; but, at no speeds, even the highest we used on the road, something like 30 m.p.h., did we get an acceleration of axle of more than 8 *g*, which would mean a dynamic loading of eight times its own weight.

The motion of the body has a total amplitude of 4 in. at 7 m.p.h., which is just about the same as the magnitude of the axle motion. It is therefore purely period with which we are concerned in determining the acceleration, the amplitude being the same for the two. Since, when the car is in the air, the period of the axle is determined by the unsprung mass, the natural periods of

[16] See THE JOURNAL, January, 1920, p. 50.

FIG. 2—SERIES OF RECORDS OBTAINED WHEN A FORD SEDAN WITH AUXILIARY FRONT-SPRING OF THE HELICAL TYPE AND NO SHOCK-ABSORBING DEVICE WAS RUN OVER AN OBSTACLE

The Same Plank as Gave the Results Shown in Fig. 1 Was Used. The Dotted Curve Is That of the Axle Movement. The Lowest Pair of Solid Lines Represents the Radiator-Cap's Motion, the Middle Pair a Point on the Body Directly over the Rear Axle and the Uppermost Pair the Shoulder of a Passenger in the Rear Seat. The Lower Curve in Each Case Was Obtained with an Inflation-Pressure of 50 Lb. per Sq. In. and the Upper Ones with a Pressure of 35 Lb.

vibration of the body and the axle should be roughly in the ratio of the square roots of the sprung and the unsprung masses, neglecting the fact that the "unsprung" mass is actually poised in equilibrium between the tires and the springs. The ratio in this case was about one-third, the measured periods from the curves being 0.27 sec. for the axle bounce and 0.93 sec. for the rise and fall of the body, while the body has a natural period when the car is at rest, as subsequently measured by bouncing it up and down in resonance, of 0.83 sec.

In Fig. 2, the lower curve of each nearly superposed pair represents a tire pressure of 50 lb. per sq. in.; the upper curve, a tire pressure of 35 lb. per sq. in. Car *A* was used on this occasion and the lowest pair of solid lines represent the radiator cap's motion, the next pair a point on the body directly over the rear axle, and the uppermost pair the shoulder of a passenger in the rear seat. It is evident that there is almost no difference in the movement of the body in the two cases. The two curves are almost exactly parallel, although there appears to be a slight advantage for the low-pressure tire in riding-quality, the maximum amplitude of motion being a little greater for the lower curve than for the upper one. On the axle, however, rather to our surprise, we found that the principal difference is that the motion is very much more heavily damped with the high pressure than with the low. I do not know just what explanation to offer, unless it is connected with the fact that, when the pressure in the tires was high, 50 lb. per sq. in. for 3½-in. tires, the wheel was probably bouncing off the ground at each cycle, while at the 35-lb. per sq. in. pressure the wheel was merely surging up and down without actually taking the tire off the ground. With the low 35-lb. per sq. in., pressure, the motion continues for three cycles of almost equal amplitude, while, on the other hand, it has almost completely died out after the second cycle with the higher pressure.

Referring again to Fig. 1, there are various ways of analyzing this motion and of determining the load to

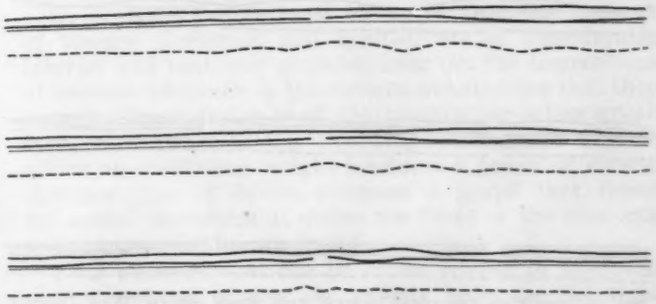

FIG. 3—ANOTHER SET OF CURVES OBTAINED WITH THE FORD SEDAN

These Results Were Obtained at a Speed of 10 M.P.H. for the Lowest Set, 22 M.P.H. for the Middle Set and 30 M.P.H. for the Top Set. In Each Group the Same Four Points as in Fig. 2 Are Represented, the Passenger's Shoulder, the Passenger's Body, the Body of the Car and the Axle. The Motion of the Passenger's Shoulder Is along a Wavy Line but the Amplitude Is Comparatively Small; the Motion of the Passenger's Body Is Practically the Same as That of the Body of the Car

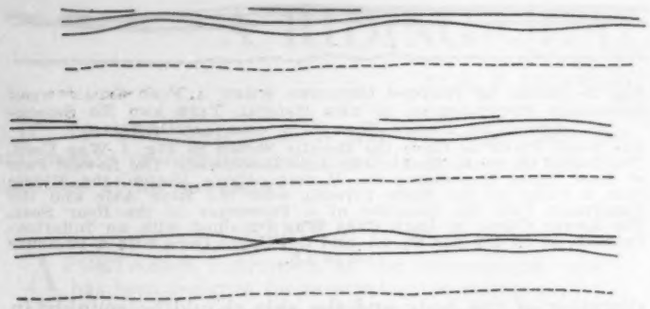

FIG. 4—RESULTS OBTAINED WHEN THE BUICK ROADSTER WAS DRIVEN OVER A ROUGH DIRT-ROAD

In This Series of Tests Runs Were Made at Speeds of 10, 15 and 19 M.P.H., the Highest Speed Giving the Results Shown at the Top of the Chart. The Upper Solid Line in Each Group Indicates the Movement of the Passenger's Shoulder and Is Broken because He Periodically Disappeared behind the Uprights of the Body as He Was Thrown Backward and Forward by the Very Violent Longitudinal Accelerations. The Middle Curve Indicates the Movement of the Body of the Car and the Lowest Solid Line Is the Path of the Radiator-Cap Travel. The Actual Amplitude of Its Movement at 19 M.P.H. Was Approximately 7 In., while the Movement of the Axle, Which Is Represented by the Dotted Line, Was between 2½ and 3 In., the Actual Depth of the Holes and the Breaks in the Road

which a passenger in the car is subjected. We assume that we all agree that the vertical acceleration of the passenger's body is one factor in riding-quality. We do not know definitely, but it is very unlikely that this is the only factor, especially in view of what Dr. H. C. Dickinson tells us; because, if I have made my rather hasty calculations correctly, the acceleration in a motion of the type he describes, with 0.001-in. amplitude and a period of about 0.01 sec., is about 0.1 *g*. only, which is insignificant. The time factor is important and the magnitude of acceleration is not the only thing, and I think it is desirable that in all this riding-comfort work we should keep in mind the desirability of making two different types of analysis; one something like this, an actual study of the motion of the car and of the body and the long-period motions that are transmitted from the road surface, and the other with an instrument of the accelerometer type, or one like Professor Lockwood's which will give also some of the effects of very short-period motions, most of which probably originate within the sprung portion of the car. The first method is the more useful in the application to the fundamental theory of the subject.

The force that acts on the body of the passenger or on the body of the car can be analyzed in several ways. The most obvious method is to take such a curve of body motion as we have been showing, differentiate twice and get the acceleration, but that is very difficult to do with

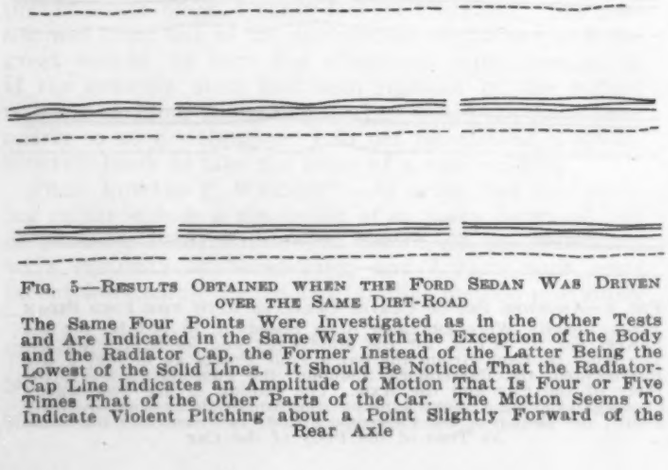

FIG. 5—RESULTS OBTAINED WHEN THE FORD SEDAN WAS DRIVEN OVER THE SAME DIRT-ROAD

The Same Four Points Were Investigated as in the Other Tests and Are Indicated in the Same Way with the Exception of the Body and the Radiator Cap, the Former Instead of the Latter Being the Lowest of the Solid Lines. It Should Be Noticed That the Radiator-Cap Line Indicates an Amplitude of Motion That Is Four or Five Times That of the Other Parts of the Car. The Motion Seems To Indicate Violent Pitching about a Point Slightly Forward of the Rear Axle

a sufficient degree of accuracy. Perhaps a better method is to find the compression and the extension of the springs by taking the minimum and the maximum separation between the lines representing the travel of the body and those of the axle. Of course, no acceleration upward can occur unless compression of the springs takes place, and no acceleration downward unless the springs are extended. If we know the stretch or the compression of the springs at each instant, we know about what the acceleration and the force producing it are. The compression and the extension of the springs in these tests were found to be considerably larger at very low speeds than I had anticipated. The vertical distance between the light on the body and a line connecting the front and the rear axles was found to vary vertically so as to indicate a maximum mean-extension of about 2¼ in. and a compression of about 2⅝ in. in the front and the rear springs from their normal loaded positions. We could not get the front and the rear separately, from the observations that we took. That was when running at 7 m.p.h. only, and when very little

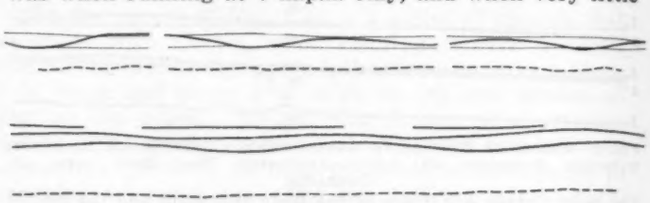

FIG. 6—COMPARISON OF THE TWO TEST-CARS

In These Tests the Cars Were Equipped with Two Different Types of Spring, but Neither One Was Provided with Any Shock-Absorbing or Damping or Snubbing Device. The Upper Group Represents the Same Four Points for the Ford Sedan and the Lower Group Gives the Same Information for the Buick Roadster. The Violent Pitching of the Front End of Both Cars and More Especially the Sedan Should Be Noticed

discomfort was experienced by the passengers in the car from the passage over the bump.

Fig. 3 shows a somewhat more violent motion of the springs, having been taken for Car *A* and at somewhat higher speeds. The lowest curve in this case is at 10 m.p.h. over the same bump; the next is at 22 and the next 30 m.p.h. The motion of the passenger's shoulder is along a wavy line, but the amplitude is comparatively small, the motion of the passenger's body being about the same as the motion of the light on the body of the car.

Figs. 4 to 6 show curves taken on the roughest road we could find near Boston, a dirt road not regularly used for ordinary traffic. Car *A* was driven at speeds of 10, 15 and 19 m.p.h., and gave the results presented in Fig. 4, the highest speed being at the top of the chart. The reason for the interruption of the passenger's light was that he periodically disappeared behind the uprights of the body as he was thrown backward and forward by the very violent longitudinal accelerations. The lowest of the solid curves in Fig. 4 is that of the radiator-cap movement, and the actual amplitude of travel of that part at 19 m.p.h. was in the neighborhood of 7 in., although the axle curve had an amplitude of 2½ to 3 in. only, the actual depths of the breaks and the holes in the road. The motion of the front of the car was very much more violent than that of the rear.

Incidentally, as a result of this work, we are very pessimistic as to the value, for practical results, of continuing to work with a single idealized bump, as so many spring investigations have been made in the past and as we started to do this work. We think that very little basis exists for direct comparison between the results we obtain from running over a single plank and

those obtained when running over an actual road, although the former are invaluable for building up a theory.

Fig. 5 shows, at the bottom, results from Car *B* at 2 m.p.h., driven very slowly so that it actually mapped the contour of that same road. On this car the body light was below that on the radiator cap. The radiator-cap line shows again that the amplitude of the motion of the radiator-cap light is four or five times that of any other light on the car. The motion seems to include violent pitching about a point very slightly forward of the rear axle. It was very noticeable in Car *A* that the pitching was responsible for most of the motion of the passenger, who was continually thrown forward and backward by the angular acceleration.

Fig. 6 shows a comparison of the two cars with two different types of spring, but with neither car equipped with any shock-absorbing or damping or snubbing device. Car *A* is represented by the lower set of curves. In both cases the front of the car did the violent pitching, particularly in the case of Car *B*. On Car *A*, the rear light was in considerably more violent motion at 20 m.p.h. than was the light parallel to the rear seat in the heavier car.

PRESIDENT CRANE:—Here we have an opportunity to discuss two instruments or two methods of testing that obviously cover entirely different characteristics. Their capabilities may overlap each other, but it is clearly evident that Professor Lockwood's instrument can detect variations in the body movement that would never show on the lamp photographs as those photographs were taken.

A MEMBER:—Some 12 years ago, I made some experiments along the line of Professor Lockwood's method and used an instrument that was readily obtainable anywhere, a pedometer, the operating mechanism of which is that of a ratchet actuated by a lever that has a weight at one end. As one steps forward, the weight oscillates up and down, turns a wheel by engaging the fine serrations in the ratchet and registers on a dial. It is always a very ready means of verifying conclusions such as those of Professor Lockwood. It shows remarkable results as to difference due to tire pressures and other tire characteristics. I was interested in tires at that time. I did not experiment with springs. But I could detect and measure vibrations with that little instrument accurately enough for the purpose I had in mind, that of selling tires. I obtained a difference of as much as 75 per cent in comparing different classes of tire. I merely call attention to the possibility of making use of the instrument.

PROFESSOR WARNER:—Professor Lockwood's instrument seems likely, on the whole, to measure riding-comfort better than any other that has been brought before us. I am particularly interested in the difference that he makes between upward and downward acceleration. In view of the springing of the platform, the instrument becomes essentially an integrating accelerometer, but the downward acceleration is given more weight, relatively, than the upward. What is the ratio between the force required to produce a given downward movement of the platform and a given upward movement of the weight from the platform? I think we all agree that an upward acceleration is considerably less unpleasant than a downward one. I know every one agrees that being thrown up off the seat of an airplane is more unpleasant than being pressed down onto the seat with increased force, and the general agreement is that, when one goes down in an elevator, the sudden stop is less discomforting then the sudden start downward. The question then arises as to what the relative weights assigned to the two should be, but without doubt Professor Lockwood has made a very necessary differentiation between the two and they should be taken into account as being of different relative importance for the same absolute magnitude of acceleration.

L. B. KIMBALL:—An upward acceleration of more than 1.0 *g* or a deceleration, while moving downward, of more than 1.0 *g* will move the weight and the platform downward; while a downward acceleration of more than 0.1 *g* or a deceleration, while moving in an upward direction, of more than 0.1 *g* will raise the weight from the platform. The amount of travel of the weight is integrated by the counter, 2⅜ in. of travel being equal to one revolution of the counter.

It is also interesting to note the periods supporting the weight. The upper suspension has a period of about 90 oscillations per min., which can be forced several oscillations higher or lower. This makes the readings more accurate in integrating the several accelerations of varied amplitudes. To keep the under suspension out of synchronism with the upper, the period of the lower springs was made about 240 oscillations per min.; so, the lower springs really tend to aggravate the effect of any rebound action.

PROFESSOR WARNER:—Does this mean that the lower spring is about seven and a half times as strong as the upper one?

MR. KIMBALL:—Yes.

HERBERT CHASE[17]:—From Professor Lockwood's paper, I gather that the reading of the instrument he uses depends to a large extent upon the character of the road over which the vehicle moves. Has any effort been made to determine just what part of the reading is due to any irregularities of the road surface and what part to the spring-suspension of the vehicle? I mention this because a description of an apparatus that is being used, I believe, by the Highway Department of the State of Illinois, simply to determine or integrate road irregularities, recently appeared in *Automotive Industries*.[18] This instrument incorporates a device somewhat similar to the recording mechanism in the Lockwood instrument. By employing a combination of the two types of apparatus it might be possible to differentiate between the effects of road-surface irregularities and those incident to the particular type of spring-suspension under test.

W. C. KEYS[19]:—We must all agree that the findings of Messrs. Lockwood and Kimball are of considerable interest and that they probably bear out the impressions of persons who rode in the various automobiles that they tested. Their device is of the integrating seismograph type, in contrast to the recording-seismograph type in which an oscillating weight produces a graph or record. Another type of device produces a graph that shows the actual movement of either the front or the rear axle with respect to the car frame.

Four elements that can be varied readily to affect the riding-qualities of any car already built are the tires, the springs, the rebound control and the cushion springs. The device described by Professor Lockwood and Mr. Kimball does not indicate the quality of ride given the passenger who sits upon a cushion spring. Furthermore, the device as used is too light to represent a passenger who is seated upon a cushion spring.

[17] M.S.A.E.—Engineering editor, *Automotive Industries*, New York City.

[18] See *Automotive Industries*, May 22, 1924, p. 1132.

[19] M.S.A.E.—Manager, Gabriel Snubber Sales & Service Co., Detroit.

The electric-light method of obtaining records of riding-quality, or the motion-picture method, permits a complete study of all the factors affecting riding-quality and enables one to make a detailed study of the action over any kind of bump and at any desired speed. Against either of these methods the fact can be cited that the record is short. In my own electric-light tests, 80 to 100 ft. has been the length of car travel shown in the resulting photograph. Engineers who are using the continuous graph, which indicates perhaps ½ mile of road travel, have told me recently that these records are too long for convenient study.

Regarding cushion springs, I believe that knowledge on this subject has not as yet been collected in the form of convenient scientific data. By installing good springs in the seat cushions and the seat backs, I have been able to make a good-riding car out of one that was otherwise most objectionable. Similarly, by air-binding the seat cushions of many cars, I have been able to produce very much better riding-qualities.

Harry Knepper recently pointed out to me the importance of having sufficient flexibility of the seat back so that the upholstery material will move vertically with the passenger's back for all small vibrations that may occur in the seat spring. The Chrysler roadster has this point admirably worked out; the seat back is mounted on vertical slides and is attached to the rear of the seat cushion so that the back slides up and down with the passenger. No doubt many are familiar with some cars in which no such provision has been made, and in which a person's back actually gets warm from the friction as he bobs up and down on the cushion with his back rubbing against an unyielding seat-back. A good cushion-spring of the Knepper or Marshall type, a spring approximately 5 in. high, untrimmed, will have a deflection rate of about 129 lb. per in. for each square foot of area. For a spring 6 in. high, untrimmed, it will have a rate of about 105 lb. per in. per square foot of area. The seat cushion that is most yielding and "springy" is generally not the best for riding-comfort. The best cushions that I have observed show a period of about 100 vibrations per min., the passenger being seated upon a trimmed seat-cushion in the automobile when this period was checked.

I have found it desirable not to have the top of a seat-cushion spring tied together by rigid wire-construction; also, that it is best not to have the padding too thick on top of the cushion spring because, if the tops of the various coils are not tied together too closely, the number of coils compressed by a person who sits on the seat cushion will be approximately proportional to his weight. This feature is highly desirable. I can say from experience that it is unsafe to go into production on cushion springs and upholstery for any car body without having made a comprehensive test of the riding-quality while using such springs and upholstery.

JOHN J. MCELROY[20]:—It undoubtedly will interest the speaker who advocated the use of the pedometer to know that we built an instrument about 18 months ago that was really an overgrown pedometer; it incorporated the same principle. The development led to the pedometer idea after we had experimented with the seismograph, which we gave up for the same reason stated by Mr. Keys, the records were too complicated and too long a time was required to analyze them. Our general purpose was to test each car that came into our local service-station, with and without air-springs, but we soon realized that we could not spend the time to analyze charts from a seismograph. The great trouble we had with the pedometer was in trying to stop the rebound. The interesting feature of Mr. Kimball's device is that the rebound is accentuated. I wonder if we are on the right track. It took us nearly 9 months to get the rebound action eliminated from the recording mechanism in the pedometer. We finally succeeded by using a flat spiral-spring that supported the weight element through a lever in a similar manner to that used on the seismograph, and placing the weight off-center, where it came down to a stop, so that it would neutralize the rebound. The instrument splits up the separate and distinct shocks and records them on a tape. The distance between the perforations on the tape gives a relative idea of the intensity of each shock.

In general, I am not convinced that riding-comfort can be measured with one instrument. I think that must be accomplished by using a combination of several devices and the results checked with graphic records, so that the axle movement is measured at the same time as the vibrations in the body are measured. Measuring axle movement and getting the proper relation between axle movement and vibration will, I believe, solve the problem of obtaining riding-comfort. Of course, that brings us back to the fact that a lower period with reduced damping of the spring-suspension will give the best riding-quality.

MR. KIMBALL:—I think the answer to Mr. McElroy's argument is to start with Dr. Lanchester's opinion that an acceleration in a vertical direction of 1 ft. per sec. per sec. is more or less objectionable. We have not been able to record an acceleration of 1 ft. per sec. per sec. with any degree of accuracy; so, we started with 0.1 g or 3.2 ft. per sec. per sec. This unit proved large enough to record with consistency, and yet small enough so that none of the cars tested failed to register on a concrete pavement. Our apparatus tends to accentuate the rebound in proportion to the amount of acceleration involved and the number of oscillations it is carried out. We believe that any movement of the sprung mass should be recorded if it incurs an acceleration of more than 0.1 g.

Regarding the question of lowered period and reduced damping, the difficulties of lost traction and sea sickness are generally encountered. Lost traction is due to the inability of the rear wheels to follow the contour of the road, usually occurring where the period of the rear suspension is lower than 70 oscillations per min. Damping tends to eliminate this condition, as it also tends to lessen the tendency toward sea sickness. This is sometimes experienced at periods of less than 60 oscillations per min. I have had cases called to my attention in which cars having an approximate rear suspension of 90 oscillations per min. had their original cord-tire equipment changed for balloon tires. In these cases the period of the rear suspension should be determined by taking the sum of the initial deflection of the springs under load and the initial deflection of the tires. The addition of the tire deflection was enough to bring the period of the rear suspension below the point where the occupants were affected.

Lack of damping sometimes permits violent oscillation in traversing a series of bumps when the period of their occurrence synchronizes approximately with that of the suspension. I have seen the accelerations reach a value at which the occupants were precipitated against the top of the car. This, incidentally, was observed to

[20] M.S.A.E.—Chief engineer, Westinghouse Air Spring Co., New Haven, Conn.

have occurred on the rebound. A very successful way of lessening this action is by cutting down the initial deflection of the springs and introducing the maximum amount of interleaf friction.

The remedy for poor riding-qualities is not to be found in the over-emphasis of the importance of any one factor, but rather in the proper evaluation and combination of all the factors involved.

TESTING OF AIR-CLEANERS

BY A. B. SQUYER[21]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

A GOOD air-cleaner is an essential part of automotive engine equipment. Many types of cleaner are on the market and the user must choose on the basis of the three essential requirements of maximum cleaning efficiency, minimum attention from the operator and minimum power-loss.

With respect to these three essentials, the development of a laboratory method of testing air-cleaners starts with the premise that the test for efficiency should consist of feeding in a weighed quantity of dust, and an account be made for that which is not separated by the cleaner. The first method was to insert a white outing-flannel cloth in the airstream from the cleaner. The varied degrees of soiling of the cloths from different cleaners were a relative measure of their efficiency. This method was found unsatisfactory for several reasons.

An attempt was made to use a dry centrifugal cleaner of predetermined efficiency, in series with the cleaner under test, to catch a portion of the dust escaping. It was found, however, that the efficiency of the centrifugal cleaner varied with the fineness of the dust, and that the dust escaping another cleaner was so fine that almost none of it was caught by the centrifugal cleaner.

It was discovered that soft felt ⅜ in., or more, thick was 100-per cent efficient when used as a filter. A filter was arranged using soft felt ⅜ in. thick interposed in the air line from the cleaner under test to the carbureter. The filter was arranged so that the felt could be removed and weighed. In making a test, the apparatus was set-up, using an air jet for suction instead of an engine. A venturi meter was inserted in the line to assure correct air velocity. The apparatus was operated without feeding dust until the weight of the felt became constant. Then, 50 grams of dust was fed into the cleaner and, from the increase in weight of the felt filter, the efficiency of the cleaner was computed. The best cleaners, as determined by this method, were then checked by the use of an engine under load on a Sprague cradle-dynamometer. Determinations were made also of the cleaner's effect on the horsepower of the engine, as well as of the water consumption of washers, or any other factors that might affect the operation of the cleaner or engine.

While it is possible and may appear feasible to some to embody more refinement in the method outlined, the author believes, due to his experience and observation, that this is not essential to the determination of a satisfactory air-cleaner. In making the final choice, the most efficient cleaner may not be selected. Operators do not, as a rule, give the necessary attention to such auxiliary apparatus. If a cleaner requires little or no attention from the operator, it might be the wiser choice even though it may be slightly less efficient. In cases where tractors are called upon to operate under extremely dusty conditions, it has been found advisable to combine a centrifugal cleaner, which requires no attention, with an oily fiber filter. This combination gives an overall efficiency of 99.9 per cent and the filter need only be cleaned and re-oiled once a week.

The method of attachment to the engine is very important, in that tight connections must be provided so that unclarified air shall not leak into the carbureter inlet. The author recommends standard flange connections, or their equivalent, throughout.

THE DISCUSSION

O. C. BERRY:—Will Mr. Squyer tell us what type each one of the cleaners shown in Fig. 4 represents? If that is permissible, I think it will be very interesting.

CHAIRMAN J. H. HUNT:—I should also like to ask Mr. Squyer to tell us what the efficiency of the various cleaners is on lighter loads, for the different types, because in motor-car work the efficiency at the lower air-flows becomes relatively much more important than in the case of tractors.

A. R. SQUYER:—No. 1 is a dry centrifugal-cleaner made of tin. It had a soldered seam down the side and was painted inside, which caused it to have the lowest efficiency.

No. 9 is also a centrifugal cleaner but is made of spun aluminum, very smooth inside. It has no paint and in use becomes very brightly polished. That, to my mind, is one of the reasons it is a much more efficient centrifugal-cleaner than No. 1; another reason is that it automatically rejects the dust from the cleaner by the exhaust-nozzle and not only separates the dust from the air but actually takes out dusty air through the vortex that is set up in the cleaner. With this dust is also that outer film of air, so that the dusty air is taken out, rather than separated from the dust entirely while in the cleaner. In No. 1, the dust is separated from the air entirely.

No. 2 is a dry centrifugal-cleaner of another type. No. 3 is a centrifugal cleaner having a rotating element inside.

No. 4 is a washer of not especially good efficiency. No. 6 is a washer.

No. 8 is a filter from a large can. The air was filtered first through excelsior and then through oakum, apparently. So far as I could determine, it looked like oakum of varying grades of fineness, beginning with the coarser; the last stage was a very fine grade. This filter must be oiled at least once in every 24 hr. No. 9 is a centrifugal cleaner.

No. 10 is another make of filter. No. 11 is also a filter. The greatest trouble with this filter is that it requires so much attention.

We are now working out a combination of the centrifugal air-cleaner and the filter, the centrifugal cleaner removing from 95 to 97 per cent of the dust. From the cleaner the air goes through the filter, which greatly relieves the load on the filter. The combined efficiency of the two will average as high as 99.8 or 99.9 per cent. The apparatus will run for a week without requiring attention, except perhaps taking off the top and pouring in a little oil. But without the centrifugal cleaner in front, it will become so badly filled up that it will seri-

[21] Research engineer, Holt Mfg. Co., Peoria, Ill.

ously choke the carbureter, the mixture will get rich, and then dilution will begin.

G. W. CRAVENS:—Is it fair to assume that the horsepower consumed by the filters is in proportion to the length of the black lines?

MR. SQUYER:—No. A cleaner might cause but little restriction of the inlet and very little horsepower loss, whereas the filters might be very efficient and still be of sufficient area that they would cause very little loss. A cleaner amply large for the engine must be chosen, that is, as large as possible and still maintain the efficiency.

Filters, of course, are just as efficient at the lighter as at the heavier loads, but some of the centrifugal types of cleaner showed a much lower efficiency at lighter loads than at heavier loads. The one that we are using has an efficiency as high at the lighter loads as it has at heavy loads. The reason is that, though the vortex may not have so high a velocity at the lighter loads, the tendency to pull away from the vortex does not exist. The air leaving the outside of the cleaner which goes to the center and on out also has a much lower velocity, so that at the lighter loads the tendency to pull the dust from the air does not exist and, therefore, the efficiency is maintained very well.

MR. BERRY:—It seems to me that two or three things might be added to what has been presented. In the first place, great pressure has been brought to bear on the manufacturer of carbureters to force him to make carbureters that will not restrict the engine. In making some tests on air-cleaners I was surprised to find that the restriction of the air-cleaner itself was greater than even our most restricted carbureters. I think, however, that a mistake has been made in overemphasizing the importance of a free carbureter, and that too much importance should not be attached to an extremely small restriction on the part of the air-cleaner.

The inference has been drawn that air-cleaners require a readjustment of the carbureter and that any change in the restriction of the air-cleaner would also require a readjustment of the carbureter. I would like to point out that it is possible to install an air-cleaner on a carbureter in such a way that not only is readjustment not necessary if the air-cleaner clogs up, but the carbureter can be adjusted properly with the air-cleaner on and still maintain exactly the same mixture when the air-cleaner is taken off. To do this it is necessary to air-bleed the bowl of the carbureter, not to the atmosphere, but to the chamber just below the air-cleaner itself.

CHAIRMAN HUNT:—I believe it is correct to say that if the air-bleed referred to by Mr. Berry is brought into a passage where the air-flow is perfectly parallel and the connection perfectly smooth, it will not be necessary to put on the additional air-bleed; but if any projection that will cause a fin is there, or if the flow is not uniform, causing suction or impact against the point where the connection is made, you will not get the conditions that you are seeking and may have to do some further patching.

C. P. GRIMES:—I wonder whether we have been entirely consistent in this discussion. Some men have spoken about test cleaners made of cloth or of felt and have remarked that they plug up and restrict the flow of air. Mr. Berry has remarked that the air should not be restricted by a dust separator; and then he proposes a cure for the over-rich carbureted mixture so that the outfit can be operated with a very high restriction on the cleaner, which, of course, is the same as on the carbureter and would reduce the performance of the car.

In a car with the production of which I have recently been connected I think this would be very detrimental indeed. I think it would be much better to realize that we should either have a cleaner that does not restrict, or agree to take care of the cleaner every day if necessary rather than have the carbureter compensate for a high restriction that would eventually decrease the performance of the car.

O. M. BURKHARDT:—I would like to repeat the question Mr. Hunt asked as to the change in the efficiency of the cleaner with a lowering of the air-flow. That has not yet been answered and is a vital question.

The centrifugal cleaner, it seems to me, has the power of throwing rather heavy particles of dust. When it does not have the centrifugal force, as is the case when idling and in light-load performance, how efficient is it?

MR. SQUYER:—In a centrifugal cleaner that catches the dust in a little pot at the bottom, the air enters at the top, is put into a vortex around the cleaner and goes out at the top. In going round, the dust is thrown to the outside, of course, and gradually settles. With a cleaner of this type, I have found that it is not so efficient at the lighter loads as it is at the heavier loads. On the other hand, in the same cleaner, with an exhaust-nozzle at the bottom, so that a suction is caused which takes out the dust from the outer skin of the air on the sides, I found that the efficiency fell off no more, if at all, at lighter than at heavier loads.

A point that tends to make the cleaner as efficient on the lighter as on the heavier loads is the fact that, although it is true that at heavier loads the velocity is higher, the suction and the drawing from the outer portion of the cleaner are greater. On the lighter loads, the velocity drops considerably, and the tendency to pull from the outer portion of the cleaner is not so strong as at the heavier loads. The efficiency of the cleaner, therefore, and the centrifugal separating principle still seem to apply equally.

NEIL MACCOULL:—I wish to express appreciation of the fact that Mr. Squyer has included in his paper some accounts of experiments that he has made in developing this final method and has recounted his failures and the reasons he has rejected certain methods. It has been my experience that most men who are not connected with experimental work do not realize the great amount of time that is required to develop methods; if more reports like this were given, showing the reasons some methods were rejected, it would save considerable time for those doing similar work, by enabling them to avoid similar pitfalls.

A. J. SCAIFE:—Much emphasis has been placed on efficiencies around 97 or 98 per cent, causing the air-flow to be restricted and the power reduced. Why do we place so much emphasis on the high efficiency of the air-cleaner? If manufacturers of other devices show us a saving of 10 per cent in fuel and 10, 15 or 25 per cent in other things, we grasp them very readily. But unless air-cleaners show 98 per cent, we do not consider them. This efficiency may be necessary with tractors, but in the case of trucks and passenger cars, it seems to me that, if we could get just 50-per cent efficiency and not interfere with the air-flow and have an air-cleaner that would not require attention and would double the life of the engine, it would be worthwhile. I do not know why we demand 97 and 98 per cent. Why not give us a cleaner that is 75 or 80-per cent efficient, will not restrict the air-flow, requires no attention and just give us that much more life?

CHAIRMAN HUNT:—The reason that those specifications have been drawn is that this is one way of evading the issue. That is the talk that the air-cleaner man hears. Mr. Scaife's remarks are certainly in order. Much can be gained by going part way down the road of improvement.

PROF. A. H. HOFFMAN:—I wish to echo what Mr. MacCoull has said and pay tribute to the engineers of many companies. As a matter of fact, the work that we did in California would be in its first stages yet if we had not been able to get information from Messrs. Squyer, Tice and Patch and others who were extremely generous in giving us the results of years of their work. The "absolute cleaner" that we used in our tests was partly due to the results of the work of some of these companies. I certainly take off my hat to the engineers of the companies who cannot get on a housetop with a megaphone, as we can at the educational institutions, and shout forth to the world the results of their work. As a usual thing, all the engineer in commercial work can do is to bring his report to the office, where it is filed. The rest of the world knows nothing about it.

T. S. SLIGH, JR.:—Is any information available relative to the behavior of a supercharger as an air-cleaner? I think the two things might work together very well.

MR. BERRY:—I would like to hazard a guess. It seems to me that the type of supercharger we are now advocating, the type used by Mr. Duesenberg on the car that won the 500-mile race at Indianapolis, is an instrument for pulverizing the fuel very finely and mixing it very thoroughly with the air. If any dust is blown into this supercharger it will also be mixed very thoroughly with the air.

Another kind of supercharger can be designed which will throw all the fuel on the manifold wall. This type of instrument will also take out all the dirt. We had better use the supercharger as an atomizing device and depend upon something else to take the dirt out of the air.

PRESIDENT H. M. CRANE:—I would like to second Mr. MacCoull's remarks and give credit to the Meetings Committee for attempting to get this kind of paper. Without question, the greatest thing that you can do for an engineer is to tell him of the things that you have tried to do and failed in doing, with all the reasons surrounding the circumstances. I think we owe a vote of thanks to any engineer who will come to our meeting and tell us frankly wherein he has been unsuccessful. It is very easy, as you have discovered, to get persons to come before us and tell us about their wonderful successes; there is no trick about that. But the educational value of that kind of thing is not to be compared with the educational value of a long and arduous task with many obstacles on the way. The latter is worth hundreds of times what the other is worth. I would like to thank Mr. Squyer personally for what he has done. I hope it will inspire other members to do likewise. If we carry on our meetings and discussions in that way, we shall get ahead immeasurably faster than we ever have got on yet.

F. H. DUTCHER:—Is it not pertinent at this point to ask why so great stress is laid on the restriction caused by an air-cleaner? The average passenger-car in this Country seems to operate most of the time at a load of approximately one-quarter its capacity. Consequently, I fail to see why a reduction of even 10 per cent in the maximum power as obtained on the dynamometer, for perhaps 3 per cent of the time, should reject a cleaner that gives manifestly better cleaning-characteristics than one that will cause a 1 or 2-per cent drop in power that is very rarely used.

S. W. SPARROW:—My education on air-cleaners has almost all come this morning, so I do not think that I shall have any detailed comments to make, except possibly as regards the effect on the power-drop of the installation of the air-cleaner. It strikes me that it would be preferable or desirable in all cases to specify the actual pressure-drop over the air-cleaner rather than the power decrease, not because it is not the power decrease that we are interested in, but because of the fact that, when the entrance to the carbureter is restricted, not only is the weight of the air entering the engine decreased and the power changed, but the mixture-ratio also is changed. This will probably also cause a change in power; the amount of change will depend upon the mixture-ratio before the change was made, namely, before the air-cleaner was added. These two offects are superimposed, and you may get very different results as regards the power-drop, depending on the fuel-air ratio before the cleaner was installed.

F. C. MOCK:—It is perhaps worthwhile at this time, while we are considering the application of air-cleaners to passenger cars, to point out that, if we wish to absolutely avoid loss of power, if we wish to make an air-cleaner function at 3000 r.p.m. with an imposed drop in pressure at the carbureter-intake of ½ in. of mercury, it will be a very much larger air-cleaner than anybody has put on that same size of engine before. In all probability, the tubing connections will be large and clumsy. It is not a matter of design but of capacity. I think we shall have to accept some sort of compromise between reasonable size, maximum power and efficient cleaning.

In view of the fact that a passenger-car engine is operated for scarcely ½ per cent of the time at its upper range of speed, it might be satisfactory to fit a bypass valve in the passage between the cleaner and the carbureter and operate it from the carbureter throttle, so as to throw it wide-open when full speed is wanted. The amount of dust encountered in that sort of service might not hurt the engine. On a motorbus, the condition is somewhat different as full throttle is used more of the time, but I do not believe that motorbus engineers will demand the high power-outputs that passenger-car engines are supposed to have.

PRESIDENT CRANE:—In mentioning superchargers, Mr. Berry brought to mind a very interesting phase of this question of air-cleaners. We clean the air in practically all air-cleaners by power, that is, some work must be done on the air to remove the dirt. The poorest kind of power that can be used on an engine is that of the air-stream flowing into the engine. We all are fighting our way to a higher volumetric efficiency, yet we interfere with it. Wherein the supercharger bears on this is shown by the Moss-type supercharger that has been used on the Liberty engine in recent altitude-flights. It is very interesting to note that, by using the power in the air-stream of the exhaust, the air-stream in the inlet can be pumped up to such an extent as practically to carry the engine to an altitude of 15,000 or 20,000 ft. without the actual volumetric efficiency in the weight of oxygen dropping below what is obtained at sea-level. For that reason, it is conceivable that, if we are using very high efficiencies, we shall want to use the power of the engine that is produced by the burning of gasoline in some mechanical way to do the separating, rather than use part of the very feeble power in the incoming air. A very little of the latter will go a long way toward lowering the power, efficiency and flexibility.

RIDING-QUALITIES RESEARCH

BY JOHN A. C. WARNER[22]

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

THE ascertaining of the factors that determine the riding-qualities of automobiles and the methods employed in studying these factors, and consideration of the lines along which research should be directed in an effort to improve riding conditions, are proposed in this paper with a view to encouraging further helpful discussion of the riding-qualities problem.

Relative to the first of these questions, the factors treated in this paper comprise (*a*) road characteristics with respect to the vehicle; (*b*) the vertical, the longitudinal and the transverse motions of an automobile, as well as small vibrations or oscillations of high frequency; (*c*) vehicle characteristics, such as springing, accessory control, tires, wheels, chassis frame, seating, body, engine and transmission, steering-gear, brakes, heating, ventilating and lighting.

Four methods most frequently applied to the study of riding-qualities are those employing (*a*) direct observation by the experimenter, (*b*) accelerometer measurements, (*c*) seismograph measurements and (*d*) photographic analysis, including motion pictures and the photographing of lights suitably mounted upon the vehicle and its load. The requirements that must be fulfilled by instruments in this work are discussed, and several interesting designs of accelerometers and seismographs are described.

In considering the problem of future research, the author mentions as the aims of such investigation (*a*) accurate analysis of the motions and the forces to which an automobile passenger is subjected, (b) determining as definitely as possible the effects of these motions and forces upon the individual, (*c*) correlating the conditions with their proper sources and (*d*) remedying the causes of the uncomfortable or fatiguing conditions. It is shown that, although some study has been devoted to certain phases of the problem, no complete solution has been achieved because of a lack of coordination in the results. Recommendations for future work include (*a*) a study of the characteristics of vehicle motions with an instrument installation that will record simultaneously both the rotational and the translational effects that may be of importance, (*b*) an investigation of the effects of the prevailing motions upon individuals, by subjecting a large number of persons to laboratory tests in which riding conditions could be accurately reproduced with suitable apparatus, and by studying the results in close cooperation with physiological and psychological experts and (*c*) an endeavor to apply this information to the investigation of the influence exerted by the various components of the vehicle upon the motions.

THE DISCUSSION

PRESIDENT H. M. CRANE:—Mr. Warner's paper has summed up the difficulties that lie before us in solving this very interesting problem. For a long time to come, probably, we shall need to return periodically to the utilization of a human measuring instrument. However, if some inanimate instruments can be made available for certain purposes, they will be of tremendous help.

I cite the case of a car in which we made changes that unquestionably improved the riding-quality very much. I know that after having made hundreds of runs in it over a road that I have known for years. I do not know at all, however, what the actual difference is in motion of that car today as compared with what it was before, either of the car as a whole or of its individual parts, and I would find it very difficult to take a car that was wrong in the way that car was wrong originally and correct it. If it were an absolutely similar case, I could probably do it; otherwise, I could not. We meet that problem every day. With every new model of car that is put out with minor variations, even in the wheelbase and the weight distribution, the question of spring-suspension must be gone through with, usually over a period of several months, before any result that is at all satisfactory is attained.

Another thing that leaves the engineer something to do in the way of exercising judgment is the fact that we have no definite goal to reach. Many car trips are so short in duration that, at present, it is a question only of whether the springs are fairly good or the top well upholstered so that one will not break his head if he is thrown against it. Minor things like the vibration of a four-cylinder engine or slight rattles here and there have insufficient time to take effect, although they would produce a bad effect on the nervous system as the result of a long ride. On the other hand, if one were compelled

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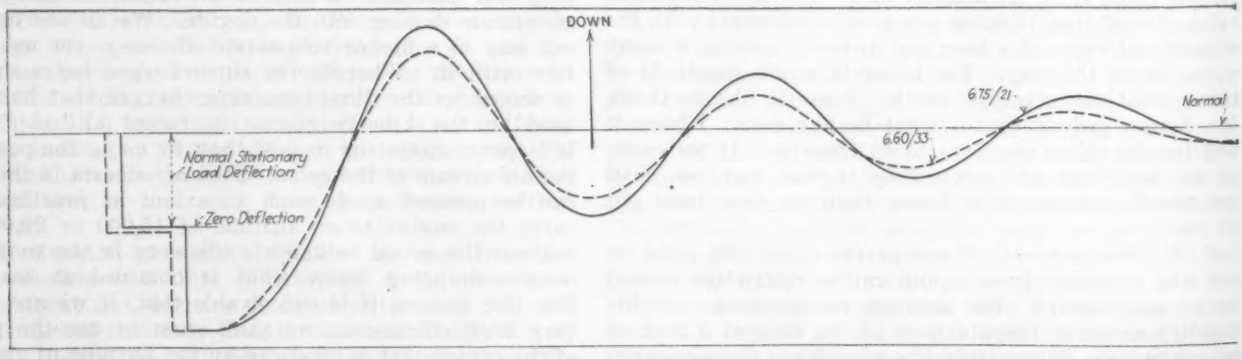

FIG. 7—CHRONOGRAPH RECORD SHOWING THE BOUNCE AND THE REBOUND WHEN THE FRONT END Two Makes of Balloon Tire That Were Made in Regular Production Work Were Tested. One of Can Be Driven at Different Speeds, in This Instance 22.77 In. per Sec., and a Pencil Recording-Securely to the Frame at the Front of the Car and the Pencil Arrangement Was Attached to the Hardwood Blocks Were Inserted between the Frame and the Axle and Clamps Were Used To of the Car Was Raised 2 in. from the Floor with a Chain Block and a Rope That Was Afterward

to ride between New York City and Philadelphia several times a week and had to prepare a car for the purpose, an entirely different set of conditions would have to be considered. Not only would the question of an occasional excessive bump have to be taken into consideration but, far more important, the matter of the minor vibrations and things such as "drumming" noises in a closed body that reach the human system through the air and not by direct contact. They all have a tiring effect, possibly on the nerves or muscles; but we do not know just what it is. In some cars they result in a feeling of exhaustion at the end of 50 miles; but, in some other car, one can ride 100 miles at twice the speed and feel fairly comfortable at the end of the trip.

JAMES E. HALE[23]:—Riding-quality is a very complicated subject. In analyzing the functioning of an automobile, small road-surface irregularities exist that must be absorbed in some way so as not to react unfavorably on the passengers; also, the ups and downs or the unevennesses of the road surface must be taken care of, because the car has to be raised or lowered as it proceeds. I have always felt it to be the duty of the tires to absorb the road-surface irregularities, as perfectly as possible. The tires should eliminate the tremors and the minor vibrations. The springs should care for the ups and downs or the long unevenesses, due to which the car must actually be elevated and lowered.

To care for the smaller road-surface irregularities, a manifestly convenient and desirable method is to use a low air-pressure; consequently, we have the balloon tire, which unquestionably helps to accomplish this purpose. To provide the other features of car operation, springs are used. Apparently, the rebound of the springs is worse with balloon tires. It is difficult to understand why. Perhaps a rather simple harmonic relation exists between the periodicity of the tires and the periodicity of the springs.

We are trying to find out something about the periodicity of tires, using an instrument that we call a chronograph; it carries a roll of paper that can be driven at different speeds and has a pencil recording-device. We bolted a substantial plank securely to the frame at the front of a car and mounted this instrument on it. Then we put hardwood blocks between the frame and the axle, using clamps to hold the frame down on the axle. This virtually eliminated the front springs. The front of the car was raised 2 in. from the floor with a chain block and a rope. Then the rope was cut so that the whole thing could drop on the floor, the paper being run over the cylinder and the pencil arrangement attached to the floor, so that the bounce and rebound of the tire was recorded on the paper. Fig. 7 shows a chart obtained when the paper speed was approximately 23 in. per sec. It was obtained from tests of two different balloon tires, and shows the actual magnitude of the deflection and the rebound. We found that the lower the air pressure is, the lower the frequency of the cycles becomes and that, the larger the tire section is, the lower the frequency is. We have found also that details in tire construction affect the frequency of the tires.

The chronograph was used first to investigate "shimmy." Front-wheel shimmy was very annoying in some cars and, although we have nothing to do with chassis design, we investigated to see what results we could get. We put the instrument on the front end of the frame and connected it to the front axle, so that we could get a record of the violence and the magnitude of the action between the frame and the axle. We found that in going along a perfectly smooth road having no holes or cracks, an action of about ¾ in. existed. It was a sort of continuous jiggling up-and-down motion, absolutely not noticeable to the driver; nevertheless, it was there and had considerable frequency. Under certain conditions, apparently, the periodicity of the tire got into a simple harmonic relation with the periodicity of the springs so that the amplitude of this vibration grew very much greater. Then, under shimmy conditions, the magnitude of the motion between the frame and the axle was as much as 3 in. on a perfectly smooth road, and the reversals were very rapid. We took the fenders off the car to try to observe this as we rode along, but it is so rapid that the eye cannot follow it. However, one side of the frame was going up and the other going down and, at the same time, the wheels were turning from side to side. We found that the speed at which violent shimmy occurred varied with the air pressure. For instance, with an air pressure of 15 lb. per sq. in. in front, a car would shimmy at 35 m.p.h. and with 25 lb. per sq. in. it would shimmy at 50 m.p.h.; but with 35 lb. per sq. in. it would not shimmy until a speed of considerably more than 60 m.p.h. was reached.

Some force other than ordinary vibration or that due to any road-surface irregularity struck by the tire, must turn the wheels from side to side. We found it to be caused by an error in the steering-gear layout. This can be proved very simply. Have someone sit in the seat of an automobile that shimmies, while it is standing in the garage under a chain block. Instruct him to hold

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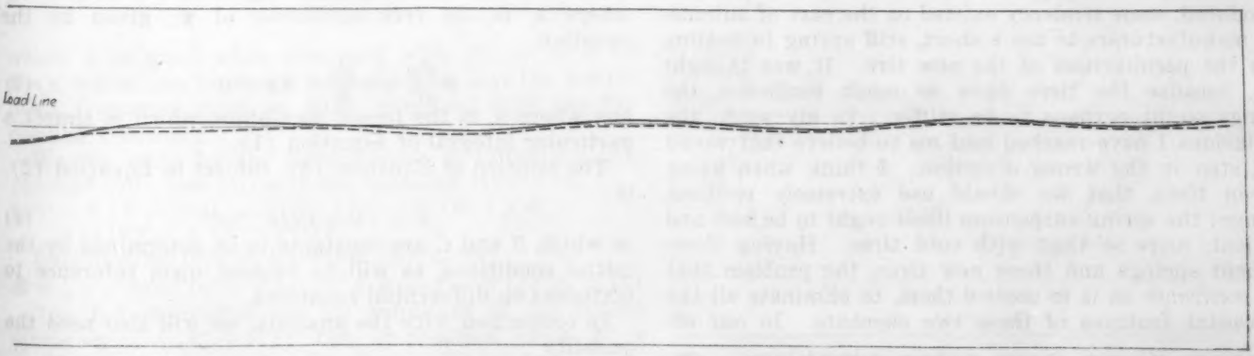

OF A CAR EQUIPPED WITH BALLOON TIRES WAS PERMITTED TO DROP 2 IN. AND STRIKE THE FLOOR These Was a 6.75/21 and the Other a 6.60/33. The Chronograph Carries a Roll of Paper That Device. In Making the Test the Chronograph Was Mounted on a Plank That Was Bolted Floor So That the Bounce and the Rebound of the Tires Were Recorded on the Paper Roll. Hold the Front Down on the Axle, Thus Virtually Eliminating the Front Springs. The Front Cut, Thus Giving the Drop That Was Necessary To Measure the Bounce and the Rebound

the steering-gear perfectly rigid. Hook the chain block to the front end of the frame and lift it, and you can see the wheel actually turn. Conversely, if clamps are put on the frame to clamp it down against the bumpers, the wheels will turn toward the other side. Having this spring action between the frame and the axle, and of a magnitude of 3 in. if the geometry of the steering-gear is incorrect to that degree, the car simply has to steer first to one side and then the other; and that is actually what happens.

We discovered other features. A shimmying automobile will shimmy irrespective of the tire size; for instance, a car would shimmy on regular high-pressure tires precisely as violently and at practically the same speed, provided balloon-tire inflation-pressures were employed. The car shimmied just as violently, irrespective of the rim width. With less weight on the front axle, the shimmy condition was very much relieved. In other words, the mass in the front axle apparently has much to do with the effect on shimmy.

We investigated wheel balance and, on this particular car, could not prove that balanced wheels help any.

This seems like a digression from the subject of riding-comfort, but I believe that the whole matter ties-in to the vibration period of the tires. In testing the periodicity of the springs of this car, in the same way that we tested the tires, by taking the tires off the car and dropping the front end directly on the rims, we got a period of 1.95 cycles per sec.; the periodicity of the tires was almost double that. I believe that the further investigation of the periodicity of tires we expect to conduct may be helpful in solving the spring problem.

W. C. KEYS[24]:—What is the relation between the load on a balloon tire pressed into contact with a surface-plate and the depression of that tire? The load-deflection characteristic of a leaf-spring runs up in a straight line, plotting inches of deflection and load as abscissas and ordinates respectively. With a balloon tire, I believe we will get a curve that runs up very steeply.

DR. H. C. DICKINSON[25]:—In this connection, some measurements have been made at the Bureau of Standards. The curve is almost a straight line for standard pneumatic-tires. In theory, it is obvious that it should be a straight line for a sphere; that is, if a balloon were compressed on a floor, the load-deflection line would be a straight line according to geometrical principles. Apparently, the load-deflection line does not depart very far from being a straight line in the case of a standard pneumatic-tire and in the case of a balloon tire it departs still less from being a straight line.

ROBERT H. HASSLER[26]:—When balloon tires were first introduced, some tendency existed on the part of automobile manufacturers to use a short, stiff spring in dealing with the peculiarities of the new tire. It was thought that, because the tires have so much resilience, the springs ought perhaps to be stiffer. In my work, the conclusions I have reached lead me to believe that would be a step in the wrong direction. I think when using balloon tires, that we should use extremely resilient springs; the spring-suspension itself ought to be soft and resilient, more so than with cord tires. Having these resilient springs and these new tires, the problem that now confronts us is to control them, to eliminate all the unpleasant features of these two elements. In our efforts to control the action of the springs and of the tires, we must not spoil or interfere in any way with the extreme softness and resilience that the public wants. The resilience and the anti-vibration qualities of the new tires are what make them so popular. Whatever controlling devices shall be used must not interfere with those peculiar qualities.

BENJAMIN LIEBOVITZ[27]:—It is fairly well agreed that, whatever other factors may influence riding-qualities, acceleration is of primary importance. The object of this discussion is to point out some of the difficulties encountered in the problem of instrumentation, and to indicate the type of design that, in my judgment, is likely to be the most successful.

Experience with the seismograph method of measuring vertical vibrations has shown that the method is very laborious and susceptible to error is an analysis of the records to provide a really satisfactory method of measuring vertical acceleration. I am thoroughly in accord with the view that the question hinges on the development of instruments for recording acceleration directly, in a simple and reliable way; and, under "acceleration," I would include longitudinal as well as vertical.

The Norton instrument is intended to meet the requirements for vertical accelerations and is capable of being extended to those for longitudinal accelerations; but, in spite of the excellence of its design, I believe that it cannot give trustworthy results. The following analysis will serve to bring out some of the errors inherent in this type of instrument. The Northern instrument is schematically equivalent to the diagram shown at the left in Fig. 1.

In the left half of Fig. 1, let

K = Stiffness of the spring, in pound-feet
m = Mass of the inertia element
r = Resistance per unit velocity of the dashpot, in feet per second
x = Vertical displacement of the body, in feet
y = Vertical displacement of the mass, m

Equating upward forces, $K(x-y)$ and $r\frac{d}{dt}(x-y)$, to the inertia reaction of the mass m, we have

$$m\frac{d^2y}{dt^2} = K(x-y) + r\frac{d}{dt}(x-y),$$

or

$$m\frac{d^2y}{dt^2} + r\frac{dy}{dt} + Ky = Kx + r\frac{dx}{dt} \qquad (1)$$

We assume *critical damping*, the condition for which is

$$r^2 = 4mK \qquad (2)$$

The solution of Equation (1) is broken into two parts,

$$y = y_1 + y_2$$

where y_1 is the *free oscillation* of m, given by the equation

$$m\frac{d^2y}{dt^2} + r\frac{dy}{dt} + Ky = 0 \qquad (3)$$

and where y_2 is the *forced oscillation*, which is simply a particular integral of Equation (1).

The solution of Equation (3), subject to Equation (2), is

$$y_1 = (B + Ct)e^{-rt/2m} \qquad (4)$$

in which B and C are constants to be determined by the initial conditions, as will be evident upon reference to textbooks on differential equations.

In connection with the analysis, we will also need the quantity

$$q^2 = K/m \qquad (5)$$

where q is also given by the equation $q = 2\pi/T_m$, in which T_m is the free period that m would have if friction were absent.

[24] M.S.A.E.—Manager, Gabriel Snubber Sales & Service Co., Detroit.
[25] M.S.A.E.—Chief of the division of heat and thermometry, Bureau of Standards, City of Washington.
[26] Robert H. Hassler, Inc., Indianapolis.
[27] M.S.A.E.—Consulting engineer, Reading, Pa.

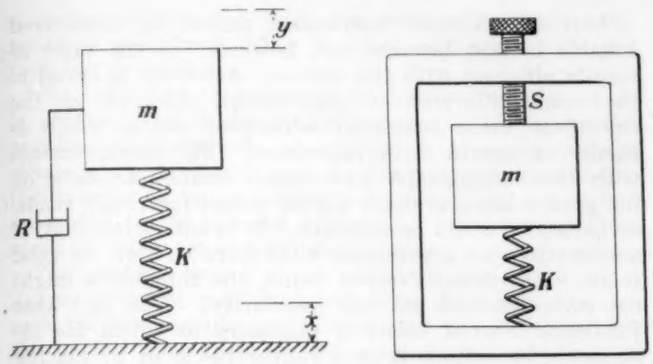

FIG. 8—SCHEMATIC REPRESENTATIONS OF TWO ACCELEROMETERS
The Instrument at the Left Is That Designed by F. H. Norton To Measure Automobile Accelerations, While That at the Right Was Developed by A. F. Zahm To Study Aircraft Landing-Shocks

For the forced oscillation, we must first know the motion of the body; that is, we must know x as a function of t. But whatever motion the body may have, any portion of the space-time curve can be resolved into its Fourier components, $A_n \sin pt + B_n \cos pt$, in which $p = n(2\pi/T_b)$, T_b is the fundamental period of the Fourier analysis and n is any integer. If the instrument is to be accurate, it must give accurate results for all the important Fourier components. Therefore, we shall consider one of the Fourier components only; that is, we shall let $x = A \sin pt$. Then, Equation (1) becomes

$$m\frac{d^2y}{dt^2} + r\frac{dy}{dt} + Ky = KA \sin pt + prA \cos pt \qquad (6)$$

It will be shown that the term $prA \cos pl$ is the troublesome one; that is, the friction which must be introduced to damp out the free oscillation of the element results in an additional force upon the element that causes serious error.

The particular integral of Equation (6) which represents the forced vibration of the weight can be found by letting

$$y_2 = E \sin pt + F \cos pt \qquad (7)$$

The values of E and of F can be found by substituting Equation (7) in Equation (6) and equating the coefficients of sin pt and cos pt separately. This gives, in view of Equation (5)

$$E = \left\{ [p^2r^2 + K(K - p^2m)]/[p^2r^2 + (K - p^2m)^2] \right\} A \qquad (8)$$

or,

$$E = \left\{ [p^2r^2 + Km(q^2 - p^2)]/[p^2r^2 + m^2(q^2 - p^2)^2] \right\} A \qquad (9)$$

$$F = -p^3rmA/[p^2r^2 + m^2(q^2 - p^2)^2] \qquad (10)$$

To simplify Equations (8), (9) and (10), we note that

$$p^2r^2 + K(K - p^2m) - [p^2r^2 + (K - p^2m)^2] = p^2m(K - p^2m) = p^2m^2(q^2 - p^2) = \Delta$$

where Δ is small when compared with $p^2r^2 + K(K - p^2m)$, which can be shown from the fact that the instrument frequency must be large compared with the impressed frequency.

We can write for the denominators in Equations (8), (9) and (10), two terms in the binomial expansion,

$$[p^2r^2 + K(K - p^2m) - \Delta]^{-1} = [p^2r^2 + K(K - p^2m)]^{-1} + \Delta[p^2r^2 + K(K - p^2m)]^{-2}.$$

Substituting this in Equation (9) gives

$$E = \left\{ 1 + [p^2m^2(q^2 - p^2)]/[p^2r^2 + Km(q^2 - p^2)] \right\} A. \qquad (11)$$

The full expression for the amplitude of the forced vibration is $\sqrt{(E^2 + F^2)}$; but, in practical cases, F^2 is negligible.

The instrument records not E, but $E - A$. Denoting this by S, we have

$$S = E - A = [p^2m^2(q^2 - p^2)A]/[p^2r^2 + Km(q^2 - p^2)] \qquad (12)$$

or, dividing by $m^2(q^2 - p^2)$, we have

$$S = p^2A/\left\{ [p^2r^2]/[m^2(q^2 - p^2)] + q^2 \right\} \qquad (13)$$

or, for instantaneous values,

$$s = [p^2A \sin pt]/\left\{ [p^2r^2]/[m^2(q^2 - p^2)] + q^2 \right\} \qquad (14)$$

But,

$$p^2A \sin pt = -\frac{d^2x}{dt^2} = -\frac{d^2}{dt}(A \sin pt).$$

Hence, the *numerator* of Equation (14) is simply the acceleration of the body, with sign reversed. Therefore, the deflection of the spring becomes

$$S = (-a)/\left\{ (p^2r^2)/[m^2(q^2 - p^2)] + q^2 \right\} \qquad (15)$$

where a is the instantaneous acceleration of the body.

In an ideal instrument, q^2 would be so large as to make $p^2r^2/[m^2(q^2 - p^2)]$ negligibly small in comparison; so, for this case, we would have

$$S = -a/q^2 \qquad (16)$$

Therefore, it is the term $p^2r^2/[m^2(q^2 - p^2)]$, or, to a sufficiently close approximation, p^2r^2/q^2m^2, that is the cause for error. This term, it appears, can reach seriously high values.

It is to be noted that q, the "frequency speed" of the instrument, without friction, cannot be increased indefinitely to decrease the error, for the deflection varies as $1/q^2$. For example, let $q = 600$, which means a natural frequency of about 100 vibrations per sec. Then, in an ideal instrument, the deflection for an acceleration of gravity would be $32.2/(600)^2$ ft. or 0.00107 in. The difficulties of recording such minute deflections accurately are by no means insignificant.

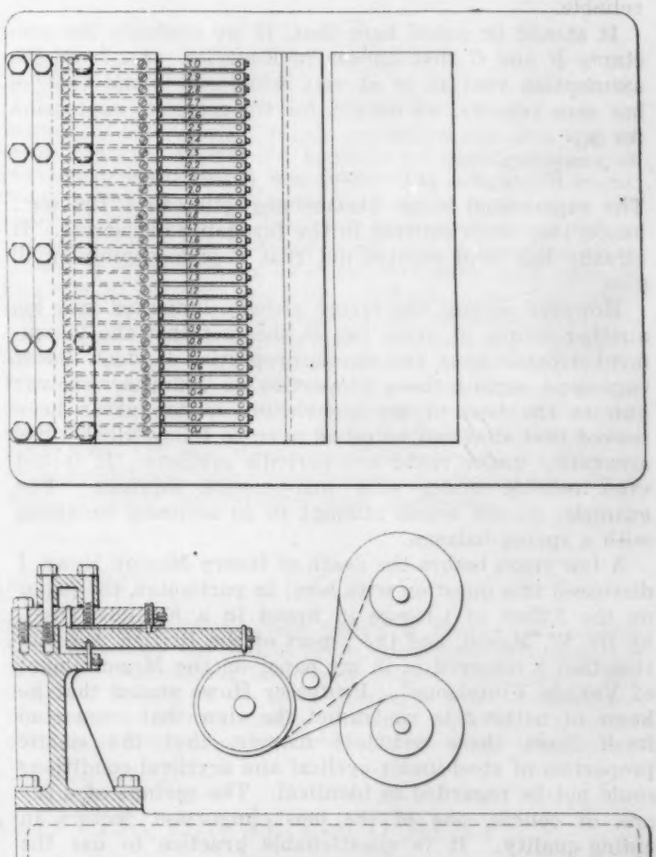

FIG. 9—A PROPOSED ACCELEROMETER OF THE MULTIPLE-ELEMENT VERTICAL TYPE
In This Design 30 Elements Are Arranged in Sequence To Represent Acceleration Ranging from 0.1 g to 3.0 g. Compressed Air, Acting on the Plungers, Forces the Styluses Attached to the Elements into Contact with a Paper Record-Roll, Thus Indicating the Value of the Acceleration by a Vertical Row of Perforations

To exhibit the instrumental error more clearly, we make use of Equation (2), the condition for critical damping. The term $p^2r^2/[m^2(q^2-p^2)]$ will be written as being approximately p^2r^2/m^2q^2, which becomes, by Equation (2), simply $4p^2$. Then, Equation (15) becomes

$$S = (-a) / (4p^2 + q^2) \qquad (17)$$

To reduce the instrumental error to say 4 per cent, $q^2 \leqslant 25 \times 4p^2$; that is, $q \leqslant 10p$. Hence, if the instrument is to be this accurate for vibrations of the order of 30 vibrations per sec., the natural period of the instrument must be 300 per sec. But, in this case, the deflection for the acceleration of gravity would be 32.2 / $(2\pi \times 300)^2$ ft., which is approximately 0.0001 in. And, with an amplification of 200 to 1, an acceleration of the value of that of gravity would give a deflection of about 0.02 in. only.

On the other hand, if a longer period is used to give more readable curves, say 100 per sec., the instrumental error for a frequency of 30 cycles becomes 36 per cent. The importance of such high frequencies as 30 vibrations per sec. will be recognized when one considers that, in traveling at say 30 m.p.h., the impact with a small irregularity in the road surface is over with in about 1/60 sec., or less. In short, if the period is made sufficiently high to obtain reasonable freedom from error, the resulting records are on so small a scale that their analysis becomes a problem, and the instrument thereby loses its advantage over the seismographic method, for instance. If the period is made long enough to give good readable records, then their accuracy is no longer reliable.

It should be noted here that, if we evaluate the constants B and C that appear in Equation (4), from the assumption that m is at rest when $t = 0$ and that m has zero velocity, we obtain, for the complete expression for y_1,

$$y = y_1 + y_2$$
$$= E\,(\sin pt - pt\,C^{-rt/2m}) + F\,(\cos pt - C^{-rt/2m})$$

The exponential terms become negligible in 1/100 sec.; hence, they were omitted in the foregoing discussion. It already has been pointed out that F is negligibly small also.

However serious the errors already indicated may be, another source of error lies in the fact that the instrument depends upon the elastic properties of steel. Most engineers regard these properties as definitely known; but, to the best of my knowledge, it has never been proved that steel can be relied upon to follow Hook's law accurately under rapid non-periodic motions. It is not even reliable under slow non-periodic motions. For example, no one would attempt to do accurate weighing with a spring-balance.

A few years before the death of Henry Marion Howe, I discussed this question with him; in particular, the paper on the Effect of Change in Speed in a Fatigue Test[28], by Dr. W. Mason, and the report of the British Association that I referred to in my paper on the Measurement of Vehicle Vibrations[29]. Professor Howe stated that he knew of nothing to contradict the view that suggested itself from these articles; namely, that the elastic properties of steel under cyclical and acyclical conditions could not be regarded as identical. The springs of a car are, of course, one of the most important factors in riding-quality. It is questionable practice to use the same medium, steel, to measure the performance of the springs.

That the Norton instrument cannot be considered reliable is best brought out, however, by the table of results obtained with this device. Attention is called to the small difference in acceleration obtained on the smoothest roads compared with poor roads, which is hardly in accord with experience. My measurements with the seismograph gave much smaller acceleration for good roads and much higher values for rough roads, as naturally would be expected. It is submitted that, if accelerations *on a passenger's lap* were as high, on good roads, as Professor Norton found, the automobile might not have attained its full popularity! The fact that Professor Norton found it necessary to shield his instrument by setting it on a rubber block, or by placing it in a passenger's lap, has an important significance in this connection; but this may have resulted, in part, from the slow speed of the film.

These objections on elastic grounds to the Norton instrument could be overcome by the use of a flexible diaphragm and air pressure, instead of using a steel spring. But the inherent errors brought out in the analysis, together with the very small magnitudes that must be amplified and recorded photographically (the theoretical errors can be reduced only by making the motions still smaller), put this method at a disadvantage.

Proposed Vertical Accelerometer

As shown in the view at the right of Fig. 1, if a weight of mass m is supported on an elastic medium, K that is arranged to be compressed further by a screw, S, and, if the entire system be moved upward under acceleration a, the following equation of reaction holds:

$$m\,(g + a) = F_k - F_s \qquad (18)$$

where F_k denotes the force exerted by the elastic medium and F_s that exerted by the screw. At a certain value of a, the weight loses contact with the screw; that is, F_s becomes zero. So, we get

$$a = (F_k - mg) / m \qquad (19)$$

This scheme has been employed in a number of instances for the measurement of acceleration.

Imagine a battery of these devices, arranged side-by-side, and that each is "set" to "go off" at different values of acceleration; and add to this a recording mechanism for indicating the separation of each weight and stop the instant such separation occurred, and vice versa. This is the method used by Zahm for measuring the landing-shocks of airplanes[30]. To the best of my knowledge, it is far the likeliest method to lend itself to the *reliable* and simple recording of acceleration; and it is applicable to longitudinal as well as to vertical shocks. It is true that it can measure acceleration in one direction only; that is, upward and not downward, or from front to rear and not from rear to front. But, since the most important shocks are all upward, the downward acceleration can exceed that of gravity but slightly, except for frame-whip, and from front to rear, this limitation is not serious.

From the present standpoint, Zahm's instrument has the disadvantage of using steel springs, and of not being able to get a sufficient number of elements into a reasonably compact space.

Fig. 2 is a sketch of a proposed vertical accelerometer. It is to be regarded, not as a finished design, but as a rough layout only, to indicate the possibilities in this direction. It is arranged for 30 elements in steps of 0.1 g, from 0.1 g to 3.0 g, where g represents the acceleration of gravity. The elastic force is obtained from compressed air, which acts on plungers. Two

[28] See *Proceedings of the Royal Society of London*, vol. 92A, p. 373.

[29] See TRANSACTIONS, vol. 15, part 1, p. 274.

[30] See *Journal of the Franklin Institute*, August, 1919, p. 237.

diameters of plunger, only, are used; the smaller diameter is used from 0.1 *g* to 1.0 *g*, and the larger one from 1.0 *g* to 3.0 *g*.

The individual elements are of different weights; that is, depths. This is done so that they will "go off" at the required accelerations. A marker is attached to each element, which would need to be set to within a few thousandths of an inch from the paper to minimize any error due to the moment of inertia of the levers. The speed of the paper should be several inches per second.

The records would show just how the acceleration increases to the maximum and then decreases, because each marker remains in contact with the paper during the entire time that the acceleration is exceeded for which the corresponding element is set to "go off." This would enable the records to be interpolated to closer values than 0.1 *g*.

An instrument of this kind, if properly designed and constructed, should yield clear and unequivocal values of vertical acceleration. Further, longitudinal accelerations could be recorded simultaneously by arranging a corresponding set of vertical levers on the same instrument.

I wish to emphasize that Fig 2 is a sketch submitted as a suggestion only, without claim for originality, with the hope of indicating a method that will yield a practical solution of the problem of measuring riding-quality.

[21] Jun. S.A.E.—Massachusetts Institute of Technology, Cambridge, Mass.

[22] See National Advisory Committee for Aeronautics Report No. 100.

F. H. NORTON[21]:—Dr. Liebovitz brings out clearly the fundamental difficulties encountered in measuring high-frequency accelerations with a weighted spring. An analysis similar to that given by Dr. Liebovitz was published several years ago by Prof. E. P. Warner and myself[22]. It was found that, with proper damping, accelerations having a frequency up to one-quarter the natural frequency of the spring would be recorded correctly in magnitude to within a few per cent, but some time-lag would be noticed. Actual tests on instruments of this type, when subjected to accelerations of known frequency and magnitude on a vibrating table, show the expected precision.

I cannot agree with Dr. Liebovitz that any high-frequency accelerations due to road shocks exist in the automobile. This lack of high-frequency vibrations is due to the fact that a rapid or sudden shock cannot be transmitted through a spring system of low natural-frequency, as are the springs of the automobile. The only way that a sudden acceleration can be transmitted to the body is by compressing the spring against the bumpers. This is clearly shown in the records from my instrument, which show in all cases a frequency very close to that of the automobile springs (about 1 per sec.), although the instrument is capable of recording frequencies 30 times as high.

In regard to the elasticity of steel, I am sure that we have no reason to doubt the applicability of Hook's law when the stresses are very low and when a precision of only 1 per cent is desired.

LONDON TRAFFIC

GOING back to the traffic carried in 1870 by the means, other than cabs and private carriages, then available for transport, which consisted of the London General Omnibus Co., the Metropolitan Railway and a few miles of the Metropolitan District Railway, the total number of passengers amounted to 90,000,000. Tramways were started in 1870, and traffic began to increase rapidly with the creation of new omnibus companies and railway extension, and in 1880, after a period of 10 years, the number of passengers carried had risen to 220,000,000. In 1890 the total was 460,000,000. In 1900 it reached a total of over 800,000,000, and in 1923 the total passengers carried by all methods of public transport reached the astonishing figure of about 2,600,000,000 in the metropolitan area, and this is exclusive of the suburban passengers brought into London by the main-line railroads, except in so far as they may travel afterward by the metropolitan services. This enormous and increasing movement of people emphasizes the fact that in large cities the greater the facilities for rapid transport at reasonably cheap rates, the greater the volume of traffic. Some radical steps will have to be taken in the next few years if locomotion in our main thoroughfares is not to become a farce, and the most rapid way of traveling above ground to be by walking, as in the very early days when no facilities at all were available. Indeed, in the City itself that time, for all practical purposes, has already arrived. No doubt much could be done by traffic diversion and regulation. Something, however, of much greater scope than traffic regulation will undoubtedly have to be undertaken in the near future. If new streets are the only solution, I sincerely trust they will not be overhead to disfigure forever our great City. If new streets must be provided, let them be underground, and such a proposition is not impossible.—Basil Mott, president Institution of Civil Engineers.

CRYSTALLOGRAPHY

THE services of the atom that has never been seen and never will be seen in the ordinary sense of the word are requisitioned in every direction with feverish anxiety and perhaps in no branch of science more eagerly than in crystallography.

The science of crystallography has much to attract students, for it teaches how matter is formed and enables us to penetrate the details of its underlying structure, yet its many fascinations have been treated slightingly. Will this new interest of the atom offering a wider outlook have the power to attract greater attention and bring a larger number of workers on the field?—*Engineering* (London).

STEEL, NON-FERROUS ALLOYS AND ELECTRICAL EQUIPMENT

THE metallurgist has done yeoman service in giving steels of wonderful strength, but the motor-car designer awaits the rigid steel with a modulus of elasticity much higher than 30,000,000, so that shafts may be reduced in dimensions without undue spring, and springs made lighter for a given stress. Also he awaits development in the non-ferrous metals, particularly of the light alloys, so that they shall have hard surfaces suitable for bearings and gears. The electrician is asked to provide a spark in the cylinder under any conditions of pressure, oil and carbon and to reduce the weight of the battery used in connection with the starting, lighting and ignition system.—*Automobile Engineer.*

A Modern Motor-Car Service-System

By H. N. Davock[1]

Service Meeting Paper *Illustrated with* Charts and Photographs

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings.]

ABSTRACT

THE paper deals with the problems encountered in dealing with service at the factory and in the field. It relates experiences had before and after reducing parts prices; how the "pirate"-parts question was combated; the steps taken to put branch houses on a comparative basis so far as expense and general overhead was concerned; how the turnover was increased and the cost of merchandising decreased, and the inventories in the various parts-departments reduced. The evolution and the inauguration of standard specifications and prices are described, as well as how the proper use of them has successfully met, and to a great extent smothered, independent repair-shop competition.

The education of dealers in the use of standard specifications and prices is discussed. A few figures are given to illustrate the progress made in the branch houses. An educational course for service salesmen is proposed.

UNTIL a few years ago, the prevailing conception of service was principally one of keeping the owner's vehicle mechanically fit and in good operating condition at all times. Any thoughts of merchandizing service at a profit were considered incompatible with this main purpose. It was believed that profits could not be made in the service department without increasing the expense to the owner, who already was standing "all that the traffic would bear." Manufacturers were elated when one of the service departments broke even and consoled themselves with the thought that money lost in service would be repaid in increased sales.

To give preferred service, motor-car factories carried what now seems a ridiculously heavy inventory of repair parts and urged their distributors to do likewise. Parts prices were criticized continually by the owners, and admittedly many inconsistencies were to be found among them. For example, the price of a right spring-shackle might be twice that of the left. "Pirate" parts were being bought on a large scale by the dealers, despite ineffectual efforts on the part of the factories to stop the practice by pleading or using threats. Small shops were competing with authorized service-stations to the extent of hurting sales as well as service. No uniformity existed throughout the Country with regard to repair charges or to the proper way of making a specified repair. Since no two shops had the same tools, inefficiency and laborious methods prevailed in one shop while contrasting conditions existed in another. Service organizations were developed with the mechanical function uppermost in mind; little attention was paid to the business side. These conditions prevailed generally throughout the industry.

It is the object of this paper to tell what has been done to make Packard service beneficial to the owner, the dealer and the factory. Having become convinced that service in all its functions could be put on a profitable basis, not only maintaining but vastly improving the service to the owner, the following steps were taken to merchandise Packard service.

First, the problem of parts prices was attacked. We were confronted with the question of what constituted the basic cost of a part. Similar parts were produced at widely varying costs. Some were produced in production runs, others in the service-parts shops and still others on an overtime basis, the combination of these variable conditions being detrimental to any uniformity of costs. We, at the factory, understood these conditions, but from the viewpoint of the car-owner the situation appeared ridiculous. By grouping similar parts, comparing their costs and still further comparing them with the cost of parts produced by other automobile companies, uniform and reasonable list-prices were set eventually. The same margin of profit cannot be set on all parts. Parts such as bolts, nuts, screws, coil springs, gaskets and the like are in the common hardware class and their prices must be dictated by the prices charged by businesses other than the automotive. Naturally, the margin of profit on such parts as these must be smaller than on other parts that are farther removed from competition. The final setting of the price of a part should be determined in relation to the expectations of the average buyer and not entirely with reference to the cost. Any merchandising organization must make no profit or a very small margin of profit on certain articles and a greater profit on others, so that a general average will afford the company a reasonable profit.

It was known that certain parts were being purchased elsewhere than at Packard stations, such as gaskets, front-end chains, spark-plugs and the like, as well as such parts as piston-pins, bushings, spring bolts and the like. We wanted this business, first, for quality reasons, with resultant protection to vehicle owners, and second, because it was known to be profitable. A meeting of the largest distributors was called and the cards were laid squarely on the table. They were told that, if repair parts were bought in large enough quantities, competition could be met, and that, in the case of gaskets and common parts of that class, the factory could quote as low or lower prices than were being quoted elsewhere. On parts like piston-pins and bushings, the factory could greatly lower prices and meet competition, better quality being considered. The distributors agreed to discontinue at once the purchase of these parts from sources other than the factory, and with this assurance the factory began revising parts prices downward in anticipation of the increased volume which was soon forthcoming. The majority of our distributors now cooperate with us to the extent of informing us when they are approached by so-called pirate parts salesmen, telling us of those prices that are found to be lower than ours. These cases are investigated, a sample part is analyzed and, if the part approaches the factory part in quality, immediate steps are taken to reduce the cost and the list prices. If this means that the margin of profit must

[1] Technical service-manager, Packard Motor Car Co., Detroit.

be reduced, the reduction is made unhesitatingly, for we must price the parts on a competitive basis or expect to lose the business. In the case of parts such as piston-pins, steering-knuckle pins and the like, which are inferior to the factory parts in quality, a quantity of them is purchased, a complete metallurgical analysis is made and displays are made up showing a cross-cut view of the factory part and the pirate part. These parts are usually mounted on boards about 3 ft. square on which a "take one" pamphlet holder is fastened. The boards are sent to all distributing points, where they are placed on the customer's counter in the parts department. The pamphlet, which deals completely with pirate parts, is invariably taken by the purchaser. As examples of what has been accomplished in the way of increasing factory parts-sales by reducing the selling price, the following are cited:

Twin-Six cylinder-head gasket: after reducing the price, sales increased 112 per cent

Rear-spring bushing: after reducing the price, sales increased 104 per cent

To check the distributors, we have a selected list of the parts most commonly sold by the pirate-parts people, which list is checked from time to time against the distributors' factory purchases, comparing the sale of these parts in ratio to those parts that can be purchased only at the factory. If it is found that a certain part is not being purchased from the factory, the case is investigated immediately. It is true, however, that very little of this wrongful practice is indulged in by our distributors and dealers today. This is not attributable to any strong-arm methods on our part, but results from meeting and beating competition.

Profits for Branch Service-Departments

The next step was to put the service departments of our branches and distributors on a profitable basis. To place them on a competitive and a comparable basis, data were secured covering the number of productive hours worked during the month, together with the direct and indirect expense given in detail, such as supervision, clerks, idle time and rent. The average rate of pay to mechanics was included also. These various expense items were then reduced to an hourly basis, and totaled for each branch and distributor. A report presenting an analysis of expense for the eight largest distributing points was made and sent to the service managers at each of these points. This practice was started 3 years ago. The report is still mailed out each month. The Chicago branch can readily see where its weak spots are and the New York City branch can consult with the Boston branch to see how such a good showing is being made in idle time and other items of expense. A chart of this report, such as that reproduced in Table 1, has admitted a lot of light where darkness prevailed before, and it has educated the service manager to view his job from a production standpoint.

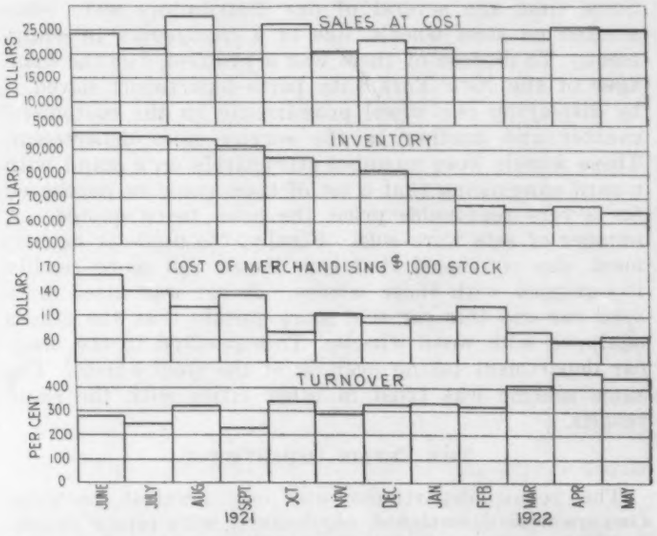

Fig. 1—How the Efficiency of the Various Parts-Departments Was Increased

As a Result of Contests between the Various Parts-Departments, the Volume of Sales at Cost and the Percentage of Turnover Increased Materially in a Year, while the Inventory Value and the Cost of Merchandizing $1,000 Worth of Stock Declined Correspondingly

To increase efficiency in the various parts-departments, a stock contest was arranged, in which substantial prizes were awarded to those making the best showing on turnover, reduction in merchandizing cost and reduction in inventory. This had to be accomplished with no increase in back orders. The principal value of this contest lay in the benefits of competition between the various stock-managers. I am afraid that if we had simply issued instructions to each of them individually, little would have been accomplished. But, when we made a game of it and let each manager know what the other was doing, it was not long before results materialized. In this way the stock-managers established their own standards for turnover and merchandizing costs, whereas these could not have been established for them. The results obtained are reproduced in Fig. 1.

Disposing of Surplus Wheels

You would not think that aggressive sales methods could be employed satisfactorily in a parts department.

TABLE 1—ANALYSIS OF REPAIR DEPARTMENT EXPENSE PER PRODUCTIVE HOUR FOR THE MONTH OF AUGUST, 1924

City	1	2	3	4	5	6	7	Average
Average Labor Rate	$0.640	$0.680	$0.720	$0.708	$0.734	$0.650	$0.708	$0.690
Direct Expense	0.367	0.481	0.500	0.536	0.604	0.465	0.386	0.474
Supervision	0.083	0.089	0.101	0.110	0.084	0.113	0.091	0.095
Clerks	0.083	0.175	0.113	0.188	0.230	0.159	0.144	0.156
General Labor	0.079	0.110	0.135	0.089	0.080	0.035	0.077	0.086
Idle Time	0.021	0.053	0.031	0.036	0.051	0.066	0.024	0.040
Corrective Labor	0.009	0.011	0.006	0.015	0.060	0.025	0.015	0.020
Miscellaneous Expense	0.092	0.043	0.114	0.098	0.099	0.067	0.045	0.079
Building	0.125	0.302	0.164	0.521	0.193	0.356	0.172	0.265
General	0.089	0.094	0.066	0.113	0.091	0.101	0.298	0.123
Total	$1.221	$1.557	$1.450	$1.878	$1.622	$1.572	$1.564	$1.552
Productive Hr.	30,757.2	24,029.5	6,300.0	13,486.2	30,519.0	17,771.5	9,351.0	19,173.0

Some time ago several of our distributors were overstocked on steel wheels, due to a changeover in equipment. To dispose of them was a problem, but the manager of the New York City parts-department solved it by displaying one wheel prominently on the customers' counter and another in the service sales department. These wheels were mounted attractively on a stand with a card announcing that a set of them could be purchased for a very reasonable price, the price being quoted. A number of sets were sold. Finally, the used-car department was convinced that cars would sell more readily if equipped with these wheels. A set was fitted on a used car and this car sold more quickly than the others equipped with wood wheels. This resulted in the used-car department taking over all of the steel wheels. The same scheme was tried in other cities with the same results.

The Repair Department

The repair department was our greatest problem. Owners were dissatisfied, particularly with repair prices, which varied anywhere from 20 to 80 per cent, depending on the shop equipment and the mood of the mechanic. Soom distributors were using home-made flat-prices, others employed the maximum-estimate system and still others were unalterably opposed to anything but the straight time-and-material practice.

A start was made by working out standard times and standard specifications at the factory. After being completed, these were sent piecemeal to the largest distributors and branches to be criticized or approved. They were not adopted until a majority vote had been accorded them from the field. The allowed times were ample for the average mechanic but they did not countenance the drone. Certain leader operations were featured, such as "clean carbon and grind valves" and "tune engine." Next the standard specifications were printed and sent to all Packard branches, distributors and dealers, with the request that they be used.

Fig. 2—An Example of Standardization of Tools for Special Repair Operations

This Illustration Shows the Packard "Carbon and Valve" Kit in Actual Use in a Service-Station

Standard Prices and Specifications

The majority of the Packard distributors and dealers put these standard prices and specifications into effect at once. They kept a standard operation-record designed by the factory to show the progress made on various operations. When a distributor could not better or meet the allotted time on a particular operation for a given number of jobs, he got in touch with the factory service-department, which either revised the time or sent a mechanic to instruct the dealer how to achieve the standard result. If Boston, Chicago and Pittsburgh could perform an operation in a certain time, it seemed logical that Baltimore could do so if properly instructed. The standard specifications and prices made it far easier for the field to sell repair work, since all elements of uncertainty regarding the work and its price had been removed. The customer was assured that the factory and not the dealer had laid down the specified operations and charges. For the first time, the field began to note and record how long it took to make a specified repair. When you can get anyone to make a check of his work, you can rest assured that efficiency will follow.

Advertising matter that drove home strongly the advantages of the Packard standard specifications and prices was prepared. In the part of this advertising that featured the evils of pirate parts and the disadvantages of taking cars for repairs to those who use pirate parts, we prominently displayed the so-called leader operations. This information was issued in booklet form and sent to the owners by our distributors.

Standard Tools

A service tool-department was organized to standardize those repair tools best adapted to Packard work. New tools that were developed by distributors were subjected to criticism by other distributors and by the factory tool-department. After selecting all the good features, these tools were produced in quantities and sold to the field at cost, plus a 15 per cent handing charge. Effort is concentrated on the design of these tools that are especially suited to Packard cars, and a further concentration is made on tools that are used for operations performed most frequently. A tool that will speed-up the performance of a "carbon and valve" job is more important than one that may be used by the average service-station only once or twice a month. The carbon and valve kit that was developed is shown in use in Fig. 2. This service-tool study and development is considered very important and absolutely necessary if we are to defeat competition.

Twice each year the standard times and prices are revised for operations as well as parts. As time goes on, it naturally follows that efficiency is increased in the repair shop by familiarity with the job or by the introduction of improved tools. Prices are reduced accordingly, so that conditions are continually made more difficult for our competitors in the repair parts and the repair fields.

At the time the standard price-system was inaugurated we knew that opposition would be encountered from certain of our distributors and dealers. It was a radical change, and the old time-and-material method of selling service was the only safe method from their point of view. To combat this expected opposition, six men were put into the field who had been trained especially for this

work. Their job was to visit each distributor and dealer, show him the many advantages of the new plan and how it should be handled to produce the best results. These men stayed with a dealer until he became "sold" on the idea and agreed to put it into execution. For a period of 2 years these field men called on each distributor and dealer semi-annually to see that the standard specifications and prices were being used. Incidentally, when the men made these visits they filled out a questionnaire reporting on the dealer's service department in general so that the factory would be kept informed of the service conditions in the field. Now that the pioneer work has been completed, only three of these men are kept in the field. It is their duty not only to report conditions but to assist the dealer in making improvements so that the maximum profit consistent with good service can be

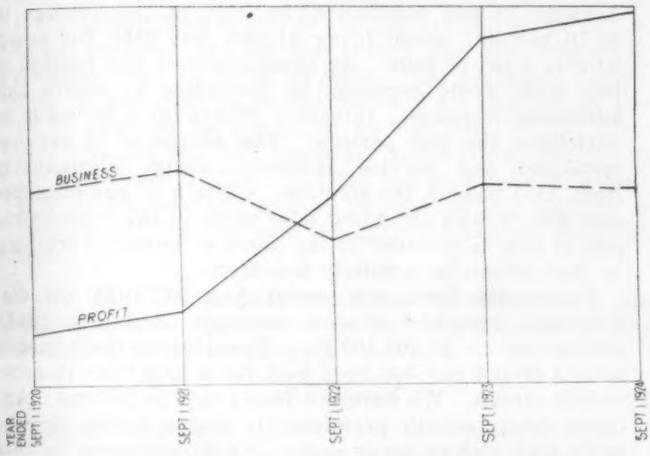

FIG. 3—RELATION BETWEEN THE VOLUME OF SERVICE-BUSINESS AND THE PERCENTAGE OF PROFIT

This Chart Shows How the Profits of the New York City, Chicago and Detroit Branches of the Packard Organization Increased from Sept. 1, 1920 to Sept. 1, 1924 with a practically Constant Volume of Business. The Details Are Given in the Following Table

Fiscal Year Ended Aug. 31	Profit on Total Annual Service-Business Per Cent	Volume of Business Compared with Preceding Year, Per Cent		Increase in Profit, Per Cent
		Increase	Decrease	
1920	1.3	...	...	...
1921	1.8	5.0	...	39
1922	6.0	...	17.0	170
1923	10.0	14.0	...	87
1924	11.0	...	0.6	9

secured in the business of merchandizing service. Good features in effect at one dealer's establishment are carried on to the next, both by these field men and by general letters from the factory.

SERVICE MEETINGS

We also hold periodical service-meetings at the factory, to which the various service-managers are invited. In addition to the mechanical side of the business, considerable time is spent in discussing better ways of merchandizing service. Subjects such as proper selling methods, perpetual follow-up of owners, service accounting, organizations and the like are discussed. Many helpful suggestions are received.

Moreover, once each year four zone-meetings are held in various sections of the Country. At these meetings, which are attended by the general managers, we attempt to drive home those fundamentals that not only will enable the dealers to render service of a higher grade to the owner but will increase their total net profit through increased efficiency.

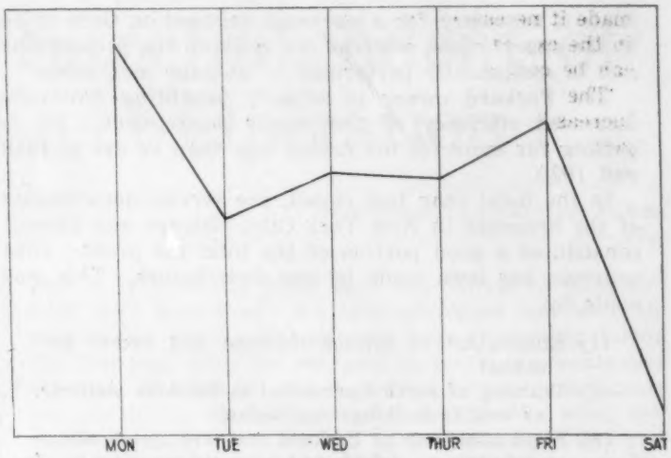

FIG. 4—CHART SHOWING THE VARIATION IN THE WEEKLY REPAIR-BUSINESS

Starting on Monday with a Large Number of Jobs, the Volume of Business Remains Practically Constant until Thursday when a Slight Increase Is Registered Followed by a Marked Decline on Friday

BUSINESS AND PROFITS OF BRANCHES

The proof of the pudding is in the eating; results tell the final story. I cite the progress of our three branches located in New York City, Chicago and Detroit, as reproduced in Fig. 3.

You will note from the table forming a part of the caption for Fig. 3 that the business handled remained practically the same. This represents business from a dollars and cents standpoint. In reality, the volume of repair work was much larger, but from the monetary standpoint it did not increase for several reasons: (*a*) the reduction of parts prices cut down the money volume of parts sales, (*b*) the standard specifications and prices reduced the former exorbitant charges for repair work, but by increased efficiency in the shops profits were increased in accordance with the figures given, and (*c*) the simplicity of the new Packard Six made possible the making of repairs in one-half to one-fifth the time consumed in repairing previous models. Conservatively speaking, we are now handling four cars in the time formerly given to one. Incidentally, the simplicity and accessibility of this car has been a great boon to our distributors. The relative intricacy of the former models

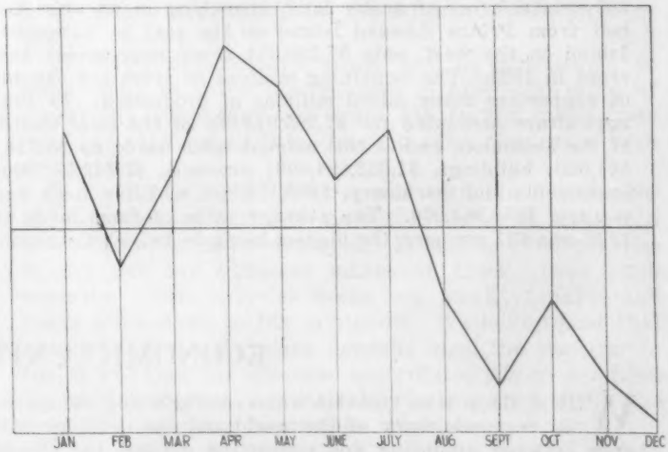

FIG. 5—SEASONAL VARIATION IN REPAIR BUSINESS

From February to April Business Increases Preparatory to Spring and the Approach of the Vacation Season Produces a Slight Peak in June. Getting Cars in Shape for Winter Driving Is Responsible for the Slight Increase in September. The Valleys Shown Are Expensive Since a Major Portion of the Direct and the Indirect Expense Must Be Borne Irrespective of Business Conditions

made it necessary for a mechanic engaged on them to be in the expert class, whereas the work on the present line can be competently performed by average mechanics.

The Packard owner is actually benefiting from the increased efficiency of the repair department. He is getting far more for his money now than he did in 1919 and 1920.

In the fiscal year just closed, the service departments of the branches in New York City, Chicago and Detroit constituted a good portion of the total net profit. Like progress has been made by our distributors. This was made by

(1) Elimination of former red-tape and excess personnel
(2) Training of service personnel in business methods, as well as in things mechanical
(3) Rigid adherence to Packard standard specifications and charges, which has won the confidence of owners inasmuch as they know uniform charges prevail throughout the Country
(4) Use of standard tools and equipment
(5) Proper management of parts department and application of sound merchandizing principles
(6) Close contact with owners by telephone, personal calls and a liberal use of direct advertising by mail
(7) Last but not least, simplicity of car design

Educational Course for Service Salesmen

The next thing on our program is an educational course for service salesmen. This will be similar to the Packard sales educational course that was inaugurated about a year ago. We are still confronted with the problem of peaks and valleys in the course of a year's business and believe that improved selling methods can bring about a steadier average. For example, note the two charts reproduced in Figs. 4 and 5, covering daily and monthly repair-business. The depressions or valleys make an expensive proposition, for, while you can reduce your productive help, a major portion of the direct and the indirect expense must be borne whether the business is poor or good. Let us assume that it costs $1.40 for each productive hour. Deducting $0.70 for labor, we have a remainder of $0.70 that covers direct and indirect expense. Further, assume that by efficiency the shop is making at the rate of $1.70 by doing the work in less than the specified time as covered by the standard specifications. Now, if it were possible by advertising or personal solicitation to increase the number of productive hours, it would certainly be profitable to spend any required percentage over the actual labor-cost to obtain the business. An increase of say 800 hr. would cost only 800 times $0.70, or $560, as no additional cost for direct or indirect expense would be incurred, since this is a fixed amount that has to be borne anyway. Eight hundred hours, sold at the average of $1.70 per hr., would bring $1,360, less $560 for labor, leaving a net of $800. An expenditure of any portion of this $800 would certainly be justifiable to secure this additional business. Intensive efforts must be made to anticipate the dull periods. The education of service-managers and service salesmen, along salesmanship lines, is, I believe, the solution. Certain of our branches and distributors are doing good work in this connection, and it now is in order to lay down a course of training so that all can be definitely benefited.

During the fiscal year ended Aug. 31, 1924, the distributing branches of the company showed a profit amounting to $1,401,109.89. The theory that branch houses do not pay has been held for a long time in automobile circles. We have not found this to be true. Another theory equally prominent is that a service department does well to break even. We do not agree to this theory either, for, of the sum mentioned above, our respective branch service-departments contributed 39 per cent, or over $500,000.

CANADA

CANADA is today the chief source for imports into the United States, as it is also the second best market for our own products. It is estimated that out of approximately 300,000,000 acres of arable land, stretching in an unbroken belt from Prince Edward Island on the east to Vancouver Island on the west, only 57,230,534 acres were under field crops in 1923. The remaining millions of acres are capable of supporting many added millions of production. In 1923 agriculture accounted for $7,365,013,000 of the total wealth of the Dominion, and of this amount lands made up $3,316,-061,000; buildings, $1,382,684,000; products, $1,342,132,000; implements and machinery, $665,172,000, and live stock and poultry, $658,964,000. The average value of farm lands in 1923 was $37 per acre, the highest being in British Columbia, where the average price is approximately $100 per acre.

The acreage under field crops has nearly trebled since 1900, when only 19,750,366 acres were under cultivation. The greatest part of the area under cultivation is given to wheat and oats, nearly one-half of the total acreage being in wheat and about one-fourth in oats. Wheat has been the greatest factor in attracting population and capital to Canada and in building up the volume and the value of the export trade. Other crops have shown a higher percentage of increase, but wheat and oats have steadily furnished the bulk of the farm revenues. Next to field crops in importance is the Canadian dairying industry, which showed a return of $226,356,000 during 1923.—T. R. Wilson in *Commerce Reports*.

ECONOMIC UNITY OF THE WORLD

WHILE there is no question whatever regarding the essential economic unity of the world and the need for balance between producing and consuming groups, the effects of conditions in one section upon another are more often indirect that direct. For example, in the period immediately following the war it was widely predicted that we could enjoy no degree of prosperity until European conditions showed a decided improvement. The actual experience of the past few years showed that this judgment was not entirely correct. The real results of a trade revival in Europe are more likely to be felt in the somewhat distant rather than the immediate future. The chief real results of an improving foreign situation during the remainder of the present year are very likely to be psychological to a very large extent rather than tangible.—W. P. Gephart, First National Bank in St. Louis.

Observations of a Superintendent of Motor-Truck Fleet-Operation

By J. F. WINCHESTER[1]

METROPOLITAN SECTION PAPER

THE discussion following the presentation of this paper at the Metropolitan Section meeting that was held on April 17 was constituted of remarks made from the floor at that time and several written contributions that were read at the meeting as well as others that were subsequently received. In accordance with the usual practice, the stenographic report of these remarks has been submitted to the various speakers for their approval and to the author for any additional comment that he cared to make. The corrected discussion, as received, is printed below. An abstract of the paper precedes the discussion so that those of the members who did not read the paper when it was printed in the May issue of THE JOURNAL can gather some knowledge of the subjects covered by reading the abstract if they do not wish to take the time to read the complete text.

[C 54 The Society shall not be responsible for statements or opinions advanced in papers or in discussions at its meetings]

ABSTRACT

SOLICITATION of sales and the delivery of the product to the customer constitute the most important operative features of the motor-truck fleet supervised by the author. Endeavor is made to install the vehicles in the various fields along standardized lines. The volume and the extent of the business and the topographical conditions of each locality determine the size and the mechanical equipment of the vehicle that is employed, and it is installed only after a study of all the conditions pertaining to its operation.

Adequate training of vehicle operators, not only along mechanical lines but also as direct sales representatives of the company, is made a feature; and so is accident prevention. These interests are prompted in various standard ways and are furthered by the publication of "house organs." After a vehicle is installed the slogan adopted is: Keep It Moving With a Pay Load.

Methods of mechanical upkeep are outlined, special tools and fixtures used are illustrated and valuable details of maintenance practice are stated. Engineering factors that affect fleet operation are discussed, as well as details relating to tire selection. A magazine system of chassis lubrication is advocated. Brakes, wheels and accessories are treated from the standpoint of design, simplicity and accessibility being the keynote. Operating costs, records and record forms are considered in general and, since adequate records are a necessity if fleet operation is to be successful, some specific recommendations are made concerning them.

THE DISCUSSION

B. K. RHODES[2]:—What is the significance of Mr. Winchester's reference to the higher cost of those vehicles, new or immediately after their rebuilding, as compared with their later life? We have calculated that we could rebuild the vehicles and operate them as cheaply during the first year after the overhaul as we could operate new vehicles. We did not find they could be maintained more cheaply during the last part of their life than when new or immediately after having been overhauled; but perhaps we have not checked that as closely as Mr. Winchester has done.

J. F. WINCHESTER:—Often we buy a low-priced vehicle and, because it was manufactured cheaply, it is not given the proper amount of inspection as it passes through the shop. On one make particularly that some people consider an economical unit, in many instances the buyer has to go over the electrical system, change the piston-rings to stop oil-pumping and do things of a similar nature. After that particular car has such work done on it, probably it will have cost from $50 to $60 more in direct labor, although it will run very satisfactorily for some time after the work is done. It has been my experience that, right after the overhaul period and despite all one can do to get the workmen to turn out first-class work, some failures always occur. Also, a certain amount of time is needed for a motor vehicle to limber-up. As a recent example, after a manager's car that he had had for about 1½ years was overhauled, he thought he could run the car just as fast as he did before turning it into the shop. He ran it about 60 miles at a high rate of speed and the engine stopped. Then the car had to be sent back to the shop to have more work done on it. Many such instances are encountered.

MR. RHODES:—That differs from our experience in that we have not had very much of that class of overhauling, most of it having been on heavy-unit trucks. We do not fit them up so that they need such careful running-in, but we do make a practice of bringing them in after they have run about 500 miles following an overhaul to check it up.

MR. WINCHESTER:—It would not be practicable in many cases to bring our vehicles in after 500 miles of operation; often they run from 150 to 250 miles from the base repair-shop into the field after they have been overhauled.

F. K. GLYNN[3]:—We fully concur with Mr. Winchester in his statement that few individual makes of truck in a given class should be employed. It has been our practice to use but two different makes of truck above 1-ton capacity. This practice keeps our stock of parts and spare units down to the minimum. We have found that successful truck operation depends upon the operator to the extent that the operator contributes life to a vehicle by careful driving, regularly lubricating the vehicle and promptly reporting mechanical troubles.

SAFETY DETAILS

We believe that Mr. Winchester's *Axe* does not fall on all his operators, for it has been our experience that a small percentage only of the people one wishes to reach will read prepared booklets. To overcome this, we issue

[1] M.S.A.E.—Supervisor of motor equipment, Standard Oil Co. of New Jersey, Baltimore.

[2] American Railway Express Co., New York City.

[3] M.S.A.E.—Engineer of motor vehicles, New York Telephone Co., New York City.

a receipt with each safety bulletin which reads as follows: "I acknowledge the receipt of my copy of the safety bulletin, and I have read the entire contents carefully." This receipt is filed, and our drivers cannot offer the excuse, "I didn't know about it." Although it may appear to some that our receipt is no greater an assurance than the book itself, I believe the very fact that the operator has contracted to comply with our rules by affixing his signature, in acknowledgment not only of having received the book but also of having read it, gives far better results.

Like any other company that operates a large fleet, we have accidents; but, considering the fact that we operate more than 8,000,000 miles per year, we have few accidents and we have reduced the number of accidents considerably by concentrated effort. We record accidents against the operator's record, and we do not tolerate more than one avoidable accident; that is, when an operator has his second avoidable accident, we recommend either that he be dropped or be given other work.

Field Repairs

We do not agree with Mr. Winchester's system of making repairs in the field. We contend that an inspector should make only minor repairs in the field, such as adjusting the ignition, the carbureter and the like. The inspector should direct the driver to make whatever repairs are within the latter' knowledge and power; all other repairs should be made in the shop. Our inspectors carefully inspect each motor vehicle once each month, and follow the above-stated procedure regarding the repair work. An inspection report is rendered and the minor repairs are handled at night; or, if a major repair is advisable, the inspector orders the vehicle into the shop.

We appreciate the truth of what Mr. Winchester says regarding modern tools and production methods. We have found it necessary many times to design special tools in our shop when nothing satisfactory could be purchased. For example, we have designed a skid-chain-repair machine, manually operated, which will remove and replace the entire set of cross links in 8 min.

Mr. Winchester:—I assume that Mr. Glynn's operation is one where the motor equipment comes in to a central garage, or is conveniently located where it can be brought in for repairs. Under such conditions, without doubt a system in which inspectors work in the manner described by Mr. Glynn would be more efficient than one in which repairs are actually made in the field.

W. E. Kemp:—Mr. Winchester made some definite remarks concerning the value of cushion compared with other types of tire, saying that he had some statistics to substantiate his statements. Are they available?

Mr. Winchester:—They were printed by the Society in the discussion I contributed on E. E. LaSchum's paper entitled Engineering Brains in Fleet Operation[4]. We have several sets of figures. We studied that problem very carefully, the figures mentioned are the most conclusive ones I have.

H. W. Slauson:—What is the largest size of truck on which the cushion hollow-center tire has been found practicable?

Mr. Winchester:—I am not able to answer that question as well as are some other operators, because we have confined our use of cushion tires to the 2½-ton truck. We have used some on the front of 3½-ton trucks and one or two sets on the rear of these trucks, but I think some operators have used them on 5-ton trucks.

Mr. Slauson:—Are dual tires used on the 3½-ton trucks?

Mr. Winchester:—Yes. One reason we have not operated the cushion tire on the rear of the larger trucks is that those trucks are governed very closely. The majority of trucks of large capacity which we operate are much more substantially built than are the lighter trucks. This has resulted in their staying out in service for a longer period, comparatively speaking, than do the lighter trucks that operate at a higher speed.

Two Types of Large-Fleet Operation

R. E. Plimpton[5]:—I have nothing to say about what is good or bad in a motor truck, but it has been brought out by several of the speakers and the point should be emphasized that we are getting to the stage where we have two different types of large-fleet operation. In one type, the vehicle returns to a central garage every night; the Fifth Avenue Coach Co. follows that practice, all its vehicles getting back to its garages for 6 to 8 hr. per day where they can be overhauled thoroughly. In the other type, such as that represented by Mr. Winchester, some of the garages are 600 or 700 miles away from what I understand to be the central overhauling station. Recently, I have studied that condition in motorbus work in which the nearest operation is about 5 miles from the central garage and the farthest about 50 miles distant. The company was working out methods to check-up the local operations, not so much to determine when an overhaul should be made, but to find out whether routine repairs were being conducted properly. Forms, weekly reports and other details were being worked out to control that condition. Will Mr. Winchester give us more information regarding how he keeps his finger on the vehicles after they get to be hundreds of miles away, assuming that the manager who has direct charge of them is a man who perhaps is more interested in selling his gasoline and oil than he is in maintaining his vehicle?

Mr. Winchester:—To review our operation further, I may say that it has grown very rapidly; the installation of trucks has rapidly outdistanced the repair-shop facilities we have. In many cases, the trucks we operate stand under open sheds. Competition has forced the use of motor trucks to meet the conditions, but maintenance facilities have not kept up with them.

Inspection Methods

Mr. Glynn questions our inspection methods. Our man, who covers 20 vehicles, does not do the same class of work that Mr. Glynn's man does. He goes out, looks over the vehicle and fills out a report that he turns in to the local manager. A copy of that report is sent in to the central office. We have one man who is continuously working on the reports made by the local repairmen to see that the marketing manager follows up the drivers and the entire organization so that they maintain the vehicle properly. For instance, we may get an occasional report that a driver does not oil and grease his truck properly. Then we instruct the manager to see that the fault is corrected. Often, "gallonage getters," as the tank-wagon salesmen are often called, will overlook the point of giving the equipment proper attention. Also, we get such reports through the periodical inspection of repair jobs, as well as from a general supervisor who is more like the Mr. Glynn's type of inspector; he covers

[4] See The Journal, October, 1923, p. 279.
[5] M.S.A.E.—Associate editor, *Bus Transportation*, New York City.

,250 to 300 vehicles and has certain other inspectors working under him.

We follow the operation of the various trucks. Trade conditions vary. Instead of continuing to operate a 650 or a 1000-gal. truck in a given locality, we transfer it if business falls off so as to keep it working up to its maximum capacity at all times. As transfers are made from one point to another, we follow those transfers through on the charts in the different central offices and keep account of the location of the vehicles in that manner. In addition, from these truck-transfer and inspection reports we try to keep what we call a life history of each truck; so, if any question arises in regard to repair work on a truck over a given period of time, we can tell how frequently the truck has been in for repair and what it cost at such times.

Performance Records

MR. PLIMPTON:—You mentioned the method of handling repairs. Do you have any method for keeping account of the performance, such as the fuel consumption or the number of tow-ins due to poor maintenance, in addition to the routine repairs?

MR. WINCHESTER:—For years, we kept voluminous records of vehicle mileage per gallon of gasoline, but we discontinued that practice recently. We try to meet the conditions that some sales organizations stated could be met, to get 11 or 12 miles per gal. out of a 2-ton truck, but now we know that to be impossible. Trying to keep records to meet those conditions is of no use. We bring a truck into the shop, overhaul it and fit it just as closely as we can. Someone here indicated that his company uses a free-running fit; but we do not, because we think crankcase-oil dilution and such things are factors in the operation of the unit. We try, so far as possible, to make it a duplicate of the manufactured job. From the different people of whom we buy equipment, we obtain blueprints that show the piston and the ring diameters, and we keep in touch with their organizations so that we will know of the latest things they are adopting and, when practical from a cost standpoint, put them into our vehicles as they come into the shop.

We keep a very close check on the operators regarding gasoline consumption. We place a sales-manager who is responsible for stocks on hand in a certain locality. He sees the mileage and the fuel-consumption records of each truck. He will not allow a man to waste gasoline if he can prevent it. In addition, he compares the mileage factor with his tickets on which the gasoline is charged out, and makes his own deductions as to whether the driver is getting satisfactory mileage; if he is not doing so, the matter is taken up with the motor-vehicle repairman. Occasionally, we have some difficulty in getting the truck promptly for the repairman to work on; but, on the whole, we have say 80 per cent cooperation along that line. It is a matter of education. When a new man is assigned to a truck, he may not want to go through this routine; but, when the truck begins to breakdown, he sees the other fellow getting the service, soon falls in line to get the kind of service that will keep his truck running.

Field Performance, Overloading and Lubrication

W. G. HAWLEY[6]:—Referring to how long a motor vehicle should stay in the field and to Mr. Winchester's statement that no given time or mileage is assigned to a vehicle, his belief being that this is dependent entirely upon road conditions, the design or the make of truck and the treatment given the vehicle by the operator, I say that the time for bringing the vehicle in for repairs is dependent also upon the expectations of the owner as to the number of ton-miles the truck should accomplish in a day. In this, I am not referring so much to the operations of the Standard Oil Co., where the loads carried are largely limited by the capacities of the tanks and the bodies, but to those operators who limit the load only by the capacity of the body, regardless of its size or the weight per unit of volume of the commodity carried. This practice makes the problem of the truck engineer a very elusive one and is one of the major causes for uncertainty as to how frequently a truck should be taken in for repairs.

It is not uncommon for body equipment, including a hoist or other mechanism, to weigh as much as three-quarters of the weight of the chassis upon which it is to be mounted. After placing upon this a load of perhaps 200 to 300 per cent of the normal rated-capacity of the chassis and operating under any and all conditions, it is not unreasonable to expect that frequent repairs may be necessary.

The laws of various States restrict the gross weight and the weight per unit of tire width; but these, unfortunately, like some other laws of recent times, do not altogether restrict. In fact, all efforts that have been made to restrict the overloading of trucks have been largely futile, and the tendency to overload seems to be increasing rather than decreasing. I do not mean to imply that truck owners and operators deliberately try to break-down their trucks, but I wish to bring out the fact that the body builders and the men having charge of the loading of trucks are inclined to look at the matter entirely from their own viewpoints, with practically no consideration for the safe carrying-capacity of the chassis. I can suggest no remedy to correct this evil except for the truck operators to provide inspection of the loading of trucks by men who have reasonably good judgment as to limiting the loads and shall give due consideration to the condition of the roads and to the weather conditions. All will realize that breakdowns under unreasonably excessive overloads usually result in very good business for the manufacturer, and that the matter is brought up here mainly in the interest of the truck operator with the belief that very material economies can be effected by reasonable reforms in this direction.

I agree with Mr. Winchester that great opportunities still exist for better chassis lubrication, but I do not agree with the implication that appears later in the paper that all these opportunities are within easy reach of the manufacturer. I believe that in most trucks of modern design a great amount of thought has been given to this matter of lubrication and that oil and grease connections are, in the main, accessibly located with due regard for simplicity and durability. We shall at least have to admit that, in all cases, some of these connections are readily accessible, and yet experience shows that in a large majority of cases these very bearings are forced into total abstinence from anything oily as soon as they are out of the manufacturers' hands. In fact, chassis lubrication is neglected so commonly that little general complaint seems to be made about the system used, regardless of what it may be. It is refreshing to have this matter of lubrication brought up for discussion in a meeting of truck operators, and it is earnestly hoped that the value of lubrication may be brought home with sufficient force to produce some practical results. Evidence of a more general effort on the part of operators

[6] M.S.A.E.—Chief engineer, American La France Fire Engine Co., Elmira, N. Y.

to keep their trucks properly lubricated is, I believe, just the encouragement that the manufacturers need to improve or add to the present systems. Under existing conditions, they can hardly be blamed for not adding further expensive complications that would result in little, if any, improvement in case existing conditions continue.

Undesirable Changes by Operators

Referring to the mention made in the paper of changes involving the removal of radius-rods and torque-arms for the purpose of simplification in some of the trucks operated by Mr. Winchester, I have no reason to believe that the changes in these instances were not justified by the results obtained. I do feel, however, that in general the making of major changes of this type by the operator should be discouraged. Such changes in most cases will affect the operation of many parts of the chassis other than the parts changed. A change like that described would require, for the proper operation of the brakes, an entire redesign of the braking linkage and leverage, and even then it is improbable that the wheel brakes would ever be as good as before the change was made, on account of the roll of the axle and its effect upon the brake application. The Hotchkiss drive should be provided with larger spring-clips than are necessary with other forms of suspension, to prevent the loosening of the springs. The universal-joint equipment that is suitable for one type of suspension may or may not be suitable for the other.

Identifying Vehicles

MR. PLIMPTON:—We all agree that unit repairs are a good thing in theory but, in an operation that covers seven States, I should think Mr. Winchester might get into difficulty sometimes in connection with motor-truck identification-numbers, especially if the requirements of the State laws include that feature. How does he handle it?

MR. WINCHESTER:—I do not understand why motor-vehicle builders continue to identify engines by numbers. We have a working agreement with the different motor-vehicle boards permitting us to change the numbers; we notify them when the number is changed and put a supplementary plate on the engine. I wish that the chassis were marked with a chassis number only and not by an engine number because, in our operation, it would save us a great amount of work, particularly of clerical nature. The great difficulty lies in handling matter from the clerical standpoint.

Referring to Mr. Hawley's remarks, I think that, in very many cases, if the builders of motor vehicles were more careful as to just how they apply the grease-cups or the lubrication fittings, it would work out to advantage even though they do not bring the oil lines out to the outside of the chassis. In many cases, if better judgment were used in that particular procedure and many such fittings were installed, it would certainly help the operator, even though it would be more expensive to the builder.

In regard to changing the type of drive and using the Hotchkiss drive, I suppose that, theoretically, what Mr. Hawley has said is true, but I have long since learned that automotive engineers do not figure out the stresses and strains involved from the same formula. The result is that parts on different makes of vehicle are built much heavier on some than on others, even though their rated capacity is the same. Possibly, in regard to the changes described, I was very fortunate in having heavy springs and parts of a type which withstood the strain imposed upon them by the Hotchkiss drive as compared with the other types of drive.

A Questionnaire

M. C. HORINE[1]:—Mr. Winchester comes before us as one of the most experienced and expert operators of heavy-duty motor-transport in this Country. What he has told us is not theory, nor is it the result of circumscribed experience. The operation of which he has charge concerns a fleet of about 1000 motor trucks that are operated in seven States and maintained in 100 garages. The organization that Mr. Winchester has built up is the result of 20 years of experience in the truck industry, an experience embracing the design, the manufacture, the servicing and the operation of motor trucks of many kinds and makes. His is an earnest endeavor to place the results of his operation before us so that it will help us to design better trucks, to manufacture them better and to service them better. I prepared a number of written questions, after having read Mr. Winchester's paper before coming here. The first is: In a large well-organized fleet operation, is it not true that the driver becomes of less importance and the quality of the vehicle itself of more importance?

MR. WINCHESTER:—The only way in which I can answer is to say that I believe in quality of the vehicle. If the manufacturer incorporates the best grades of material and of workmanship, it certainly is a great factor in enabling a makeshift driver to operate his truck continuously and in enabling us to keep the truck out of the shop.

MR. HORINE:—What can the truck manufacturer do to reduce the number of accidents?

MR. WINCHESTER:—Numerous accidents happen from time to time. For instance, we have one make of truck on which a spindle breaks very often. By using a better grade of material in that spindle we eliminated the breakage. If the manufacturer had done that in the first place, we would not have had accidents and our operating cost would not have been so high. It is difficult for a purchaser himself to determine the quality of material that is in the vehicle. He must take the manufacturer's word for it, or the word of the salesman. Careful thorough all-round engineering is the answer.

MR. HORINE:—What were the major causes of the accidents studied by the Standard Oil Co.?

MR. WINCHESTER:—A very large percentage of our accidents are caused by backing. The next major cause was negligence on the part of the driver in not observing the rules that are laid down for him. The suggestion made by Mr. Glynn to have the drivers sign for the accident bulletins is excellent.

MR. HORINE:—What is meant by the unit system of repair?

MR. WINCHESTER:—It means having a number of reserve units of various types all overhauled and ready to go into the vehicle immediately.

MR. HORINE:—What check do you have on crankcase-oil dilution?

MR. WINCHESTER:—The company I represent manufactures and sells various grades of lubricating oil. It is natural that we should endeavor to keep in touch with various conditions pertaining to crankcase-oil dilution. No one is more interested in this problem than we are. We have laboratories and apparatus scattered throughout our territory and through our sales mechanical force

[1] M.S.A.E.—Engineer, general sales department, International Motor Co., New York City.

come into contact with the various types of equipment being sold to the public, encountering intimately the various problems that arise in connection with the lubrication of any given vehicle.

From this experience we have a very good check on the average mileage that can be obtained from a given vehicle before the crankcase oil is changed. We have found that the set recommendation to change oil every so often as made by manufacturers is not a logical one.

The length of time that an oil runs satisfactorily depends upon varying factors, such as seasonal conditions, the quality of the oil and the fuel being used.

For a given type of vehicle, we endeavor to give the operating man a general idea of how long the oil will operate satisfactorily in that vehicle. We are always pleased to assist others in solving such lubricating or fuel problems as may arise in their individual car or field operation.

MR. HORINE:—How can the lubrication fittings of the more remote portions of the chassis be made more accessible?

MR. WINCHESTER:—The motor vehicle is a complicated piece of machinery that has been brought to a high state of development in a very short time. It has often occurred to me that the problem of chassis lubrication has in many cases been considered only as an afterthought. In some instances chassis brackets will be found drilled with oil-holes with no provision made for a grease-cup or other oiling device. These holes are readily accessible while no body is on the chassis, but immediately a body is applied no one, unless he be the designer of the vehicle or the mechanic who constructed it or one closely related with the company manufacturing the chassis, would ever think of looking for a point to lubricate in such a position. In another instance the gearbox had an oil-plug at its top and a hole had to be cut in the body floor to get oil into the case. In a later design a spout was run to the outside.

Many things of such a nature can be done to improve the lubrication of a unit. I do not say that it is possible to carry the lubrication devices to the outside in every case but it is possible to do so to a much greater extent than is done at the present time.

MR. HORINE:—Please make yourself clear on the cab matter. Is it the extra charge that you object to, or are you merely pleading for standardized cabs?

MR. WINCHESTER:—I would not say it is either. I believe that if a piece of equipment can be better balanced, it will make a better appearance. Many truck operators who are interested in economy would obtain greater economy if a given truck manufacturer always had on hand a cab that he knew was suitable for his vehicle and built from the ground up, instead of being purchased as an accessory. In many cases the truck manufacturer himself could give much greater value for the money, and perhaps he would not be so apt to want a large profit for a cheaper product.

MR. HORINE:—How can the changing of crankcase oil be facilitated?

MR. WINCHESTER:—By adequate foresight in designing. Provision should be made for emptying the crankcase rapidly and cleaning it readily, thus insuring the carrying out of the manufacturer's recommendation that the oil be changed at frequent periods.

The changing of oil alone is not all that is necessary. Provision should be made for the removal of any particles that may be left in the crankcase to contaminate the new oil. Without doubt a great opportunity exists for improvement along such lines.

Some makers overlook the simple matter of providing a hole in the oil-pan through which to get at the plug in the crankcase. Under conditions such as these the manufacturers cannot expect the public to carry out the recommendations given.

Value of Shock-Absorbers

A MEMBER:—What is Mr. Winchester's opinion as to the value of the various accessories that are claimed to reduce maintenance costs by lessening road shocks to the engine, such as air-springs, additional rear-end springs and rubber-trimmed wheels?

MR. WINCHESTER:—We have operated with air shock-absorbers on the front of one or two vehicles. The record showed that the vehicles operated more cheaply than when not equipped with that device; the repair cost per mile was lower, and the tire life was materially longer. But certain features about the device resulted in our abandoning it. Another factor was the exceptional success we had in the use of cushion tires. Thus, we eliminated an additional mechanical device to take care of, after using it for about 3 years. The records up to the time of the change were very good, but I would not say that they were in any way better than the results obtained with cushion tires.

Supplementary springs for the rear have never been operated on any of our equipment, and I have no basis for saying conclusively that they reduce up-keep. We operated one or two sets of the wheels mentioned by the last speaker. In my opinion, the up-keep costs were not any less; if anything, they appeared to be higher. After the impact tests made by the Department of Agriculture, I was satisfied that good judgment had been used in not adopting a larger number of that type of wheel.

Oil Dilution and Chassis Lubrication

A. WARD LA FRANCE[5]—In regard to crackcase-oil dilution and the magazine system of chassis lubrication, we have found that heat control of the engine and the regulation of the cooling system by radiator shutters and a thermostat in the circulating system have been material factors in reducing the maintenance cost and the number of replacements of engine bearings, pistons, piston-rings and similar parts. We feel that these devices have partly solved this problem. Also, that the continuous oil-lubrication of the chassis by the magazine system has solved the question of the wear of the minor parts of the chassis such as shackle-pins and bushings. I say this in strict relation to general maintenance cost and costs of transportation in general. I have here two shackle-pins that I removed today from a 5-ton truck of ours. The illustration is not at all exceptional; in fact, it is universal or at least has been so with us. This particular chassis has been on the road to my personal knowledge for nearly 5 years; it has averaged close to 30,000 miles per year, or a total travel of well over 100,000 miles. These are not high-priced shackle-pins; they are made of the ordinary run of cold-drawn steel, case-hardened and ground. Their good appearance speaks well for the magazine lubrication system.

Regarding the accessibility of chassis-lubricating devices, the pouring of a considerable quantity of oil into the large-sized magazine or reservoir has a psychological effect. I have yet to find an owner or a chauffeur so lax that he will not keep enough oil in the magazines to lubricate the parts sufficiently and continuously with oil, and,

[5] A.S.A.E.—President, Ward LaFrance Truck Corporation, Elmira, N. Y.

of course, they will not feed anything but perfectly clean oil. On 5-ton trucks during a period of 4½ years, I have no knowledge of any replacement because of the wear of a spring-pin or a bushing in either the front or the rear-springs or at either end of the radius-rod, while lubricated with this system.

Vehicles Properly Applied

JOHN STILWELL[9]:—Concerning economical transportation, which is the principal point of Mr. Winchester's paper, I feel that the one main point is the proper application of the vehicle. If the vehicle is purchased after a thorough study of the requirements of the work it has to do, and the proper body is put on it, and then the operator makes certain that the vehicle is not abused by either fast traveling or overloading, it will be found that the operation will be generally satisfactory. Many minor points must be taken into consideration in operation, but the things I have specified constitute the largest factor.

Categorical Comment

F. C. FIECHTER[10]:—It is true that the economical operation of large fleets is more dependent on the organization than on the driver. However, we must not overlook the fact that the driver plays a very important part in the economical operation of equipment, regardless of how good an organization may be.

Safety work is essential as it tends to reduce accidents to equipment and danger to human life. Also, it reduces the cost of repairs, secures reduced insurance rates and lessens the hazard of damage suits.

The best results in economy and in speed of repair can be attained wherever the unit-repair system can be operated. Vehicles can be taken out of service automatically for inspection and repairs; in this way only can breakdowns in service be reduced to the minimum. This rule is subject to exceptions; for instance, we find that approximately 10 per cent of our equipment cannot be handled in that manner, but to off-set this condition we set a time limit within which all trucks in active operation shall be inspected and necessary repairs made.

A great variance always will be found in the discussion of operating costs, due principally to the variables in cost factors but also because some managements do not aim to establish facts and are content with a lot of figures that have no definite meaning.

Without question motor-transport organizations at present neglect the vital point of defining the responsibilities of the various members in their organization. In some cases they have an elaborate arrangement of positions and titles that does not mean much in motor-transport organization. The individual accomplishments and the skill of the mechanics and the inspectors mean more than titles.

Regardless of the ability of workmen, low costs cannot be accomplished unless the proper judgment is exercised in the selection of tools and shop equipment. Unfortunately, much capital is invested in tools that are not warranted from the economical standpoint.

Records are very important, but a great danger exists of overlapping records that not only increase costs but fail to fix the responsibility on the person tabulating the information. Unless close cooperation exists between the delivery and the repair departments, repair costs cannot be kept at the minimum.

In the matter of better service-forms, a great need exists for standardization among truck manufacturers in the arrangement of this literature, so that the listing of parts shall be in the same sequence; also, parts should be called by the same name to a greater extent.

The territory covered and the class of service govern tire equipment; for example, solid tires should not be used to handle fragile commodities nor on high-speed equipment; on the other hand, pneumatic tires should not be used on broken roads or under heavy loads. High-grade cushion-tires have a very great field of application, the advantage of which truck owners have failed to observe.

Lubrication is a principal factor in keeping down maintenance costs. Chassis lubrication is very much neglected at present, but not because the manufacturer has provided inadequate means of lubrication. The reason for the existence of such unsatisfactory conditions is that few fleet-owners have systematized their method of lubrication.

If all trucks were equipped with enclosed brakes, the accident hazard would be reduced by a very large percentage as the result of better braking and the increased life of the brake-lining. It has been proved that frequent adjustments will increase brake life considerably.

Standardization of body construction will solve the cab problem. Under existing conditions, manufacturers are justified in making an extra charge for cabs.

A great demand exists for standardization of the lighting equipment. The Society should give this subject great attention with a view to having truck manufacturers standardize on such equipment. Also, to simplify the lighting equipment as much as possible would tend to lower the cost of upkeep.

It is highly desirable that the design of parts should be simplified in every way possible. Governors on trucks will continue as an accessory until speed laws are more rigidly enforced or legislation is brought about that will compel manufacturers to equip all trucks with governors.

Although many mistakes are made by engineering departments, it must be remembered that no industry has ever been known to expand so rapidly as has the automotive industry. No other industry noted for large expansion has required the amount of technical and engineering skill that was demanded in the automotive field.

Vehicles of given models can no doubt be repaired more cheaply today than was possible 5 years ago. On the other hand, present-day costs are from 300 to 400 per cent greater than they should be, due principally to neglect of the training of automotive mechanical engineers.

Best results cannot be obtained without some method of accounting; in addition to the importance of simplicity, records must be equally flexible to determine what is causing inefficient operation and maintenance.

It is true that unit-delivery costs are lower today than they were 5 years ago, on account mainly of the mechanical improvements made by the manufacturer and of higher grade men being employed in both the operation and the maintenance of automotive equipment.

Transportation Factors

G. R. GWYNNE[11]:—Standardization, maintenance and transport performance are the fundamental factors involved in transportation. The first covers the design and purchase of the equipment, from the viewpoint of service. Maintenance covers the upkeep of equipment to

[9] Consolidated Gas Co., New York City.
[10] John Wanamaker, Philadelphia.
[11] A.S.A.E.—Chief automotive engineer, Continental Oil Co., Denver.

100 per cent of the standard of the original issue so far as that is possible. Transport performance covers cost determination, control of vehicles irrespective of where they are located, and the proper application of any given motor vehicle to the work to be handled. To make any one of the three factors function properly, organization is absolutely essential.

I have charge of a fleet of vehicles operating in the States of Montana, Idaho, Utah, Wyoming, Colorado and New Mexico. From geographical and road-condition standpoints, it would be difficult to find any worse transportation problems than those that exist in these six States. The area is one-third of the total area of the United States, although the States contain but one-thirtieth of our total population. The Rocky Mountain range runs north and south through the center of this territory. These conditions form the basis of the arguments presented in this discussion of Mr. Winchester's paper.

We do not agree with Mr. Winchester in several of his statements. For instance, he says that "No given time or mileage is assigned to a vehicle." This might be practicable in congested territory such as that in which Mr. Winchester's equipment is operated, but in our operation of individual motor-vehicle units from isolated stations 500 or 600 miles from the nearest base-shop, it would not be practicable. Therefore, we take a positive stand and specify the minimum mileage on all motor-driven equipment; it is 15,000 miles for any passenger-car, 20,000 miles for a 2-ton motor-truck and 25,000 miles for a 1-ton motor-truck. This is irrespective of where the vehicles are located or what territory they serve. A minimum of 50,000 miles of actual operation before being "shopped" for rebuilding is expected from our 3½-ton trucks, all of which operate under city conditions. We have been aiming at this practice for 3 years. While we have not been able to carry it out fully, we are now on that basis and demand the service stated from our mechanical departments throughout the territory.

After the minimum amount of mileage has been reached, each respective unit of equipment is given very careful analysis by a traveling inspector. If the equipment is in such condition that it will not render 100-per cent mechanical service from a transportation standpoint, an estimate of the cost of rebuilding it is submitted by this inspector to the shop-superintendent at the nearest base-shop, and thence to the engineering department of the general office, where it is either approved or disapproved. If the rebuilding is approved, a similar piece of equipment is shipped or driven overland from the base station to the sub-station, and permanently releases the unit to be rebuilt. The latter is either shipped or driven overland to the nearest base-shop and there undergoes reconstruction.

Mr. Winchester states that "indifferent overhauls result in much lost time and a duplication of effort." His point is well taken. We cannot afford indifferent overhauls. We demand that the reconstructed vehicle be put into the mechanical condition of the original vehicle as nearly as possible. We are operating 2-ton units that have, from a repair standpoint, after 75,000 miles of travel, been operated for the last 25,000 miles more cheaply than they were operated for the first 25,000 miles.

Unit-Repair System Criticised

I have heard the unit system of repairs discussed by various manufacturing authorities, as well as by some of the foremost transportation engineers. I do not believe in the method. It is very expensive from the transportation standpoint, especially when applied in geographical conditions similar to those under which we are working. To illustrate, if the engine of a 2-ton unit goes bad at the 15,000-mile period, it is replaced with a repair engine-unit. This unbalances the remainder of the structure. Further, if the transmission fails at 20,000 miles and is replaced with a repair transmission-unit, at 28,000 miles the operator finds he has a condition of this character: the rear axle is in good condition, the transmission is in generally good condition and the engine is in fair condition, but the paint, the wheels, the frame, the radiator, the dashboard and the seat structure are in bad condition. It is then necessary to resort to "running repairs." We found from bitter experience that, when one resorts to running repairs in a hard field territory, the failures are often expensive and perplexing enough to drive the headquarters organization to distraction.

Field Service and Repairs

We service our equipment in the field by utilizing traveling inspectors. In some cases we have secured as high as 40,000 miles from 1-ton units before routing them through the base-shop for rebuilding. Moreover, we have accomplished this at what we feel is a very low cost per mile for repairs.

We designate "repairs" as the expense necessary to keep any given piece of equipment as nearly perfect as possible according to our standard specifications. This includes repairs to engines, clutches, transmissions, rear axles, frames, tanks, cabs, seats, painting and lettering. The particular charges are allocated in the chief engineer's department. The only exception we have in charges is for tires; we use two running columns headed "tires" and "repairs."

We are operating a base-station at Salt Creek, Wyo., 42 miles from the nearest rail-head, yet we stock no parts there. At our Butte, Mont., base-station we stock no parts, yet we have a large fleet of motor vehicles scattered throughout the entire State of Montana and the panhandle of Idaho. The nearest parts-depot is at Salt Lake City, 400 miles distant, and the next nearest at Denver, some 1200 miles distant. Yet our shop production is not retarded and our loss of time is remarkably low. After the first 20,000 miles, our motor-vehicle equipment usually establishes a flat curve on the "per mile repair," the only variation taking place in the different territories in which we operate.

Variable climatic and geographic conditions have largely the same effect on the motor vehicle as a whole. For instance, motor equipment operated from Lewiston, Idaho, to the Nez Perce Indian Reservation, covering Sweetwater, Lapwai, Cul de Sac and Webb, traverses a volcanic-ash territory in which the worst mud forms that I have seen, and I have driven over Illinois, Ohio and Iowa in the wettest kind of weather. Yet this equipment largely develops the same mechanical conditions that develop at Salt Creek, Wyo., in the alkali country. These two varying widely localities develop the same inherent mechanical faults as are developed in the same type of units operating at Leadville, Colo., at an elevation of from 10,500 to 12,400 ft., and at Cripple Creek, Colo., at an altitude of from 10,000 to 12,800 ft. above sea level. Thus, we have found that general geographical conditions about balance themselves so far as mechanical failures are concerned. This, of course, would not hold true in the case of travel on concrete highways, as different elements obtain in that particular case.

Maximum Mileage

The maximum mileage we assign as being obtainable under proper operating conditions, such as travel over paved roads, the employment of intelligent drivers and the like is a flat average of 25,000 miles for passenger cars from 35,000 to 40,000 miles for 2-ton trucks and from 45,000 to 60,000 miles for 1-ton trucks. For our 3½-ton trucks, it is 50,000 miles, the same as the minimum mileage already stated, because all our vehicles in this class operate under ideal conditions. These figures represent the maximum mileages of the units up to the rebuilding period. We do not as yet know the life or turn-in period of any vehicle. Maintenance in this territory is a necessity and is the foundation of successful operation. Without perfect maintenance, motor-vehicle transportation in this particular territory would be utterly impossible. On the subject of how such maintenance is accomplished, a text-book could be written.

Standard Nomenclature

Referring to Mr. Winchester's suggestion "that the National Automobile Chamber of Commerce should have a standard specification sheet to cover a given type or new model of truck," I can sympathize with him regarding the points brought out under this subject. I am firmly convinced that the manufacturers of motor vehicles have little, if any, conception of what the operation of motor vehicles entails. They have had their accountants and experts evolve various publications for their own benefit. On the other hand, if some of the manufacturers or production engineers were forced to sit at Mr. Winchester's or my desk and to attempt to decipher the Chinese hieroglyphics found entered in the various parts-books, they would indeed change their methods and adopt a standard nomenclature and standard parts or serial numbers that would simplify the ordering of parts. Further, they would come to some standardized form, with views of the various assemblies, showing the relation of one part to another. We are dealing with the maintenance of motor equipment by the mechanic of average ability who is not very well versed in reading books and drawings. Therefore, the trouble that ensues when ordering parts is a great burden that we, as operators, carry. Heroic efforts should be made to simplify the purchase of parts by the operator from the manufacturer. We have determined the "mortality" of parts. If the purchase of these parts can be made easier by the standardization of nomenclature, parts numbers and parts books, it will be of material assistance not only to fleet operators but to the individual operator who has but one or two vehicles. The Society should lend its support to such a movement.

J. E. McLaughlin[12]:—The company I represent operates a standardized combined delivery-system for department stores. My statements will be based on conditions pertaining to that line of business, which may account for seeming differences of opinion in some instances. Our fleet consists of electric trucks for city package-delivery, ¾-ton gasoline-driven trucks for suburban package-delivery, 2-ton gasoline-driven trucks for furniture delivery and 2-ton electric trucks for freight.

Commenting upon the main points of Mr. Winchester's paper, I presume he means the salesman-chauffeur when he uses the term "operator," in saying that "the economical operation of large fleets is more dependent on the organization than on the operator." But without the cooperation of the motor-vehicle drivers, the best of fleets are lost. Good drivers help to make good motor-vehicles better.

Accident Prevention

It cannot be denied that, as stated by Mr. Winchester, educational work in the interest of safety is essential from both economical and public-welfare standpoints. This subject should interest all, and such education should be extended in spite of all obstacles. A continuous safety-campaign is maintained by the company I represent and has been in effect for the past 3 or 4 years. Prizes are awarded to those who come through a designated period with the fewest accidents. Literature such as has been mentioned is distributed. The plan works out very well.

Unit-Repair-System Obstacles

I do not agree that the unit-repair system is a necessity. To get the best results from a motor vehicle and to keep accurate records of its performance, it is recognized generally that the vehicle must be handled so far as possible by the same driver and must be used under the same sort of topographical conditions throughout its life. When the unit system of repairs is enforced, these important phases are nullified. For example, no sure method exists of determining to what extent crystallization or fatigue has affected the strength of the metals of the parts subjected to shocks except that of breakage in service, and no practicable way of restoring such parts to their original strength exists. Imagine the case of a driver who, after having driven a certain motor vehicle carefully for a long time over good roads, has had an unavoidable accident that necessitates a change of the rear-axle unit. Such a unit, assembled and ready to be installed, lies waiting in the service-station and it is used to replace the damaged unit. Suppose it happens that this repaired unit which is substituted has been in service in a vehicle operated by a reckless driver and has been driven in rough country. Also, that shortly after the unit has been installed to replace the damaged one, an axle-housing breaks. To all appearances, the unit was sound when used for replacement, but the breakage is due to the shocks and the stresses it had received in its former service, although it did not fail at that time. Thus, if units are changed promiscuously, no accurate record of truck performance or of the driver's performance can be kept. This phase of the subject should be given adequate consideration.

I agree with the statement in the paper that no specific time can be assigned after which a vehicle should be brought in for repair. Running repairs are necessary in all motor-vehicle fleets, but any work that requires more than adjustments or the replacement of minor parts should be done in a centrally located maintenance station and in a standardized and an economical manner.

Generally Desirable Features

It is correct to say, as Mr. Winchester does, that we are at great variance in our discussions of operating costs, because like fields of activity are seldom compared. Perhaps a remedy can be found. Regarding the definition of the positions held in a motor-transport organization and the titles used, perhaps some standard dictionary of motor-transport terms can be compiled. The National Retail Distribution Association has a committee on terminology and, as the members of that association have had similar difficulties, although engaged in a dif-

[12] Superintendent of maintenance, Eleto Co., New York City.

ferent business from that of Mr. Winchester's company, this committee might be able to give helpful advice.

It is agreed that proper shop tools and suitable records are essential to secure low cost, and that close cooperation between the delivery and the repair departments is necessary, although I am not sure that the delivery department has control of the most important factors that influence the unit cost, excepting the drivers. Tire selection is indeed important; and so is good chassis lubrication.

On the subject of chassis lubrication, Mr. Winchester says that better lubrication would result and time would be saved if the builders would bring *all* connections for these devices to suitable locations on the outside of the chassis. But this would not be practicable, because some of the parts on which these devices are installed rotate. In other instances, the length of tubing required, the angles needed and the like would make the maintenance cost greater than the value of the additional time now required to get similar results.

Brakes and Other Features

The enclosing of brakes is a good idea, but it will not allow as free cooling, and it is a very difficult matter to enclose an external-contracting type of rear-wheel service-brake. Such a brake is the one most exposed to road dust and mud and receives the hardest usage. A theoretically ideal brake is now on the market that is entirely enclosed; it works on the principle of the multiple-disc clutch, in oil; a brake is located on each side of the differential, inside the case.

Without question the wood wheel has greater resiliency than has the steel wheel. By absorbing the road shocks as close to their source as is possible, the wood wheel helps to protect the entire vehicle.

We find that hand-operated horns give satisfactory performance on our vehicles.

Mr. Winchester says that the cab should be an integral part of the chassis and not be classed as an "extra." But I think that cab and body design should be influenced by the user. Competition is the life of trade, and the selection of some parts should be left to the tastes of the individual.

The ultimate cost of electric lighting on motor trucks is much higher than the cost of some other systems unless the trucks are used extensively at night, in which case the electric system of lighting gets a chance to break even. It is true that all such design should have simplicity as its keynote, as Mr. Winchester says, but why insist on electrical equipment? It is not simple, but exceedingly complicated and costly.

In the past, governors have not been built any too substantially. They have not improved truck performance in all cases. However, a few are made at present that perform well, but even these are not desirable at all times.

Three Periods of Extensive Upkeep

As stated by Mr. Winchester, machinery has three periods of extensive upkeep: (*a*) when first installed, (*b*) when overhauled and (*c*) when being run-in after overhaul. It is obvious that period (*a*) is expensive. As to period (*b*), the expense depends upon what the term "when overhauled" implies. Mr. Winchester is right in saying "There is no logical reason that period (*b*) should be materially more expensive than period (*a*)." The cost of overhaul should be uniform, except for differences in the cost of material and in wages. Although a higher wage rate may be paid, this is compensated for by the increased efficiency that is brought about, partly by the avoidance of excessive labor-turnover.

If complete overhauling is referred to for period (*b*), meaning that all parts are dismantled, examined and reassembled when the overhaul period arrives, I say that this period should never materialize because certain parts, such as shackles, bolts, bushings, bearings and brake-linings, fail first; other parts fail progressively. Therefore, period (*b*) should be continuously forestalled by making repairs progressively as may be found necessary.

For period (*c*), the expense should be a very minor consideration. If the repair work has been done properly, even though an unnecessary "overhaul" has been made, aside from using perhaps 3 or 4 gal. of gasoline and a small quantity of lubricating oil, not more than 1 or 2 hr. of time should be charged because the vehicle can then be put into service and run-in while on a regular delivery route.

In department-store service, an adequate fleet must be maintained in reserve to care for the "peak" seasons and to avoid the troubles that are encountered when outside transportation has to be engaged. Thus, a sufficient surplus of vehicles is provided so that such conditions can be handled satisfactorily; otherwise, less efficient methods might have to be used and the results obtained would not be nearly what could be expected under the conditions noted.

Daily operating sheets that record all necessary information are essential and prevent excessive costs. Cooperation between the drivers and the maintenance and the executive officials, and adequate equipment, are prime necessities.

A. Schindel[13]:—I submitted the questionnaire of the Metropolitan Section to our garage superintendent and herewith state the questions and his answers and suggestions.

Engine

Question:—Do ball-bearing or babbitted main-bearings give the best results?

Answer:—We find that ball-bearing main-bearings reduce friction and also reduce the cost of maintenance.

Question:—Should the engine have a removable head or a removable block with valve-port plugs?

Answer:—The removable block with port plugs is a more compact unit, and a damaged valve can be repaired in a few minutes; but, with a removable head, that would take from ½ to 1 hr.

Question:—Should the engine have pressure lubrication, splash lubrication or splash and pressure lubrication combined?

Answer:—Splash lubrication is a very good system, but it needs a large oil reservoir, and this means considerable loss when the crankcases are drained. We find pressure lubrication is the best, provided the crankcase or oil reservoir is built of small capacity and the circulation is good and an efficient cooling system is provided. A 50-per cent saving in oil should be effected with pressure lubrication. At present it takes 12 qt. of oil to fill the crankcase but, with the pressure system, the oil reservoir would require only 3 qt.

Clutch

Question:—Should a disc clutch run in oil or be dry?

Answer:—Judging from our experience, a small plate-disc clutch running in oil is much cheaper and smoother, provided it is taken care of properly.

[13] Superintendent, L. Bamberger & Co., Newark, N. J.

QUESTION:—What is the best rear-end drive, for up to say a 1-ton chassis; worm, bevel, or internal gear?

ANSWER:—We find the bevel gear to be the best of the three; it delivers more power to the wheels than the worm gear does, and it has fewer moving parts than the internal gear has.

QUESTION:—Which give the best result throughout, ball or tapered roller bearings?

ANSWER:—Ball bearings have smaller contact surfaces than have taper roller-bearings and, the less the friction is on a motor vehicle, the less its cost of operation will be and the more miles per gallon of gasoline it can run.

QUESTION:—Should the transmission be of unit construction with the engine, or mounted as a separate unit amidships?

ANSWER:—A four-speed-forward transmission swung amidships is a stronger unit, is much more accessible for a ¾ or a 1-ton unit and also acts as a saver of gasoline.

SPECIFIC SUGGESTIONS

The following improvements are suggested:

An automatic shut-off, so that, when the vehicle stops for more than 2 or 3 min., engine idling will be prevented.

Automatic oilers, a wick or a gravity system to all cups. Oil is preferable to grease; it tends to give a longer life to bushings, all bolts and spring parts, and to secure more car-miles per gallon of gasoline.

A graphite bushing appears to be desirable.

Interchangeable engines and rear axles that are, to fleet owners, reduced in price; to permit quick changes and provide reserves.

A flange on the fan-belt pulley, to prevent the belt from slipping off.

Electric, and not acetylene, lights. Electric lights are cleaner, cheaper and less of a fire hazard; also, the appearance is better if the running-board is clear.

METHODS FOR ANOTHER FLEET

A. B. TILT[14]:—I agree that the economical operation of large fleets is more dependent upon the organization than upon the driver. I have found this to be the case in the control and operation of Swift & Co.'s fleet, which consists of approximately 4000 units, about equally divided between trucks and salesmen's cars, distributed over every part of the United States and most of Canada. Widespread distribution offers some very serious organization and maintenance problems and, without a most complete organization, it would be almost impossible for us to maintain control or to obtain economical operation by depending beyond a certain degree on the driver.

Regarding the great variance in the discussions of operating costs because like fields of endeavor are seldom discussed, very likely it will be a long time before the total operating cost of equipment in different lines of business can be put on a comparative basis; too many variable factors prevail in different lines of industry and influence the total cost of operation. But I feel that it should not be difficult for us to put certain items of cost on a basis such that a fairly close comparison could be made of trucks in every line of business. Tire, gasoline, oil consumption and repair expenses, when compared on a mileage basis for trucks of equal capacity operating under fairly uniform conditions, should enable us to help each other by a free discussion from time to time as to what we are doing to reduce these particular items of expense.

Probably the only item referred to that would need a full discussion to determine the basis for calculation is that of repair and maintenance expense. I believe it is fair to charge all items of maintenance and repairs under the heading "repair expense." Some operators contend that only direct repair-expense should be shown as such, and that inspectors and the like should be charged as an operating expense under some other heading. Possibly this is fair, but we who have to do with fleets that have so wide a distribution naturally have to depend on regular accounting departments to furnish us with the necessary information. Such information should be reduced to the simplest possible form; otherwise, it defeats its own purpose. Therefore, we have all our different departments that use motor-truck equipment show all repair and maintenance items of any nature whatsoever under the repair-expense heading.

Another item that I feel can be compared to advantage is that of "actual depreciation." We go over our records on trucks traded out, from time to time, and determine the actual depreciation in time and in money of various trucks of different capacity. To simplify the accounting, naturally, we use the straight-line depreciation. It is evident to anyone that this is unfair, in a way, because the better class of equipment naturally has a much longer useful-life than has the medium-priced or cheap equipment. To avoid being misled, we determine the actual depreciation of the equipment that we have traded out.

I cannot agree wholly with Mr. Winchester in his belief that the lack of properly qualified and trained men in the truck-operating field is the fault of the truck manufacturer. I am sure that the truck operator is free to draw any trained men from the truck manufacturer's organization that he feels can be used to advantage. The large truck-operator has a business organization that is many times the size of that of the truck manufacturer, while, on the average, the permanency of employment he offers is greater than that of the truck manufacturer, although the remuneration is lower. A goodly number of capable men who would fit into a truck-operating organization extremely well are in the service of truck companies but, so far, few operators are willing to offer sufficient inducement to secure men of this caliber. However, I feel that the time is coming when the higher executives of companies operating large fleets of trucks will realize that they must have good men if they are to enjoy the great reduction in cost that is possible in the operation of a very large fleet of motor trucks.

The following "Ten Commandments of Driving" which are sent out by Swift & Co. to drivers of motor-vehicle equipment may appear somewhat humoresque, but they have more than accomplished the desired effect.

TEN COMMANDMENTS OF DRIVING

(1) Drive on the right side of the road; it's just as good as the left
(2) Slow-down when approaching a crossroad; it is nearly as dangerous as a railroad crossing
(3) Look out for children. You can never tell what they will do, and you are always in the wrong if you hit one
(4) Try to help instead of hinder the traffic officer; he is there for your good, and he's got a tough job
(5) Be sure that your "dimmers" really dim; it's no joke driving into a blinding glare, as you probably know

[14] Automobile department, Swift & Co., Chicago.

(6) Read and obey the warning signs; they are not put up as ornaments

(7) If you feel you've got to speed, do it where it won't kill anybody but yourself

(8) When making repairs, stop where your car can be seen from both directions; otherwise, you may stop longer than you anticipate

(9) Speeding around corners is a straight route to the hospital. Don't race past a stopped street-car. Some day the jury may call it manslaughter

(10) Use discretion. The fact that you had the right of way won't bring anybody back to life, least of all yourself

Service-Department Reports

F. A. Whitten[15]:—Our engineering department takes more interest in service-department reports from our own organization and from outside sources than it does in any other sort of literature. The greatest lack that the engineering departments of truck-manufacturing companies find is the lack of service records and information. The failure to keep such records on the part of a great percentage of operators is lamentable. Even when records are kept, they are frequently of little use because of lack of detail or knowledge of all the surrounding circumstances.

One of the most misleading things it is possible to do is to compare operating records from one service-station with those of another without including additional information that is, usually, not specified in such reports. Mr. Winchester has brought this out clearly. He calls attention to the fact that results obtained in one locality may be entirely different from those obtained with the same vehicle under the same supervision in another locality. Records kept by observers like Mr. Winchester are not usually subject to criticism of this kind. I have seen the operations of certain of his company's branches, and believe it has one of the best-organized service-departments of which I know.

Frequently, I have told our dealers and users that the fuel and oil consumption could be reduced from 30 to 50 per cent in the average installation if the user would do two simple things: first, keep a daily record of the amount of oil used and of the amount of gasoline put into the tank of every truck, and then tabulate these figures against the daily odometer reading; and, second, have some executive look at these figures every week. The report he examines should be a cumulative one, showing last week's figures in comparison with those of the previous week and those for a considerable period back of that, and also for the corresponding week of the previous year. If this is done, any radical increase or decrease in the fuel or oil consumption will cause someone to want to know the reason of it. An inquiry of this kind goes a long way toward correcting trouble. I have seen repeatedly cases in which the very fact that such a record was kept actually produced better economy.

The following out of the foregoing simple routine would, in time, decrease other operating-costs to a remarkable extent. Such scanning of records produces such remarkable results that it invariably arouses curiosity regarding other details; once this curiosity is aroused, beneficial results are almost certain to follow.

Service Procedure

The large manufacturer can afford a well-organized service-department and, through this department, he soon learns that the operators' service troubles and problems are the manufacturers' troubles as well. Our method of handling these matters may be of interest. First, every detail of any new design or any change in design is considered carefully from the service standpoint. Naturally, the final details are the result of a compromise between accessibility, cost of repair parts, manufacturing methods and first cost, but the intention always is to establish such a balance between these various elements as will be best for the ultimate user. This viewpoint is entirely a selfish one on our part, because we realize that, if the customer does not like our truck, he will not long remain our customer.

The matter of establishing this balance between the various factors of any design is a very difficult problem. If we were to adopt every suggestion for improvement, or every improvement we could think of, these would come so fast that it would be impossible to do any manufacturing on a large scale and the price of the completed vehicle would be so high that we could not sell it in competition. Further, it has been our idea to eliminate complications and not to add anything to the truck which is not essential to its operation as a freight-carrying vehicle.

For a long time, our service-department has been tabulating every complaint and trouble reported. These are grouped by chassis divisions and parts in an arbitrary way. The engineering department receives a monthly tabulation of the complaints for the previous month against practically every part of the chassis. This information is invaluable to the engineering department, as a constant recurrence of any trouble gives warning of a need for correcting something that is radically wrong.

One of the things we have to be most careful about is not to rush in and change things on the basis of these service reports, because the men who send them in are very likely to tell what they believe causes the trouble without having made a thorough analysis of the entire situation. Whenever we make a "correction" of troubles without any investigation, we almost always fix the wrong thing. Because of the necessity for a careful investigation of complaints, we are frequently criticised because we do not make the obvious change right away. Criticism is also frequently directed at the factory because the change does not come through as soon as the user or the dealer thinks it should. This comes about because the making of what apparently is a very simple change may involve very complicated modifications in tool equipment in the manufacturing department before the change can be made. Delays and expenses of this kind are usually not evident to the outsider who has no manufacturing experience, and it is practically impossible to make such an outsider understand the difficulties of the manufacturer with changes of this kind.

Records of Complaints

The keeping of records of complaints is a very difficult task inasmuch as many trouble-reports are not of much use except when they are accompanied by additional history. Hence, it is our practice to tabulate these complaints at length, adding to them as complete a history of all of the known surrounding circumstances as can be obtained. Frequently, it is necessary for the service department to exchange several letters with the maker of the complaint before this history can be obtained. It will be seen that this is a large and difficult task, yet we find that if records are not kept in this way they are of practically no value.

Whenever the engineering department starts in on

[15] M.S.A.E.—Chief engineer, General Motors Truck Co., Pontiac, Mich.

any contemplated change or new design, the service-department records are consulted first. The total shipments of the parts involved are first looked up as an indication of the actual amount of trouble that occurred with these particular parts. Then follows an investigation of the trouble and the complaint files that pertain to the articles in question. We always discuss the history of this particular part with the service-manager and his assistants, as well as with any of the road men who happen to be available at the time. This verbal discussion is to obtain a better picture of the situation from the customer's viewpoint than mere reports or figures can give. Statistics of this kind are not always a true index of the amount of trouble, because the trouble may be of a more or less minor nature in itself; but, because of some peculiarity or its influence on something else, it may be a very irritating one to the operator or the mechanic.

When any change is made, one of our endeavors is to make the new parts interchangeable in the simplest possible way with those already in use, as this is highly important from the service standpoint. It is not always possible to do this, but we always endeavor to make corrections in such a way as to involve the least possible change of other parts.

The Engineer and His Difficulties

The engineer finds himself in a difficult position when making either changes or a new design. He is deluged every day with suggestions for additions, changes and improvements. He is reminded daily by the management that this thing, that thing and the other thing costs too much. He is told almost every day by the sales department that the truck is lacking in certain almost essential details, that certain parts of the truck are not good enough for the job and must be improved and, almost in the same breath, that the truck costs too much.

Another impression I would like to correct is that the engineer likes to put in a lot of machinery. To make my viewpoint clear along this line I have frequently said, in talking at meetings of salesmen, service-men and others, that the engineering department was hoping some day to build a really good truck and that, if we could ever find a way to build a truck that did not have an engine, a clutch, a transmission, a propeller-shaft, axles, wheels, a radiator and other parts, it would be a first-class truck from the operators' standpoint. The whole trouble with the motor truck of today is that it has too much machinery about it. Yet we are constantly under pressure to add more machinery to it. For this reason, the engineer finds himself in another embarrassing position. In spite of this difficult position, I would not have any of you form the idea that you could get a real engineer to do anything else, because he likes the job or he would not be an engineer. He also learns to like a fight because, if he did not fight, he could not hold his job. There is no one in the entire truck business that the engineer has more respect for or likes to talk to any better than the service-man, whether he be the mechanic on the job or the superintendent, and all of us go out of our way to meet these men on every possible occasion.

Mr. Winchester:—The discussion submitted is gratifying, as it sets forth the ideas of many individuals who operate under conditions that vary greatly. It covers the situation from the viewpoint of the large city central-garage operator, to that of others whose territory covers a very large area and is largely separated from a central repairshop.

Some feel that unit repairs are not economical. It is difficult to see how a scattered operation can be operated economically on any other basis. If all units in a vehicle were in perfect balance and capable of performing economically and gradually wearing out all at the same time, I could agree with the dissenter. Unfortunately, this ideal condition does not exist. Why tie up a large investment by excessive lost-time while a part is being repaired, such as a magneto, a carbureter, a vacuum tank, a generator, a battery or any other part? If an engine has had a connecting-rod burn out and go through the crankcase, or the cylinder and the piston have been scored on account of a lack of lubrication, which has resulted in the bearings and other parts being affected, repairing these parts may tie up the vehicle for a long period of time, and in some instances the remainder of the parts may be in such condition that they will outwear the new engine that has been placed in the chassis. Surely, when such things occur, it is necessary to carry along business. If no units are carried, the business has to be handled by a reserve vehicle or by engaging outside hauling facilities. Certainly, the judicial handling of units represents a smaller investment than a complete vehicle. Besides, within a certain radius it is cheaper to transport such units than it is to dispatch a complete vehicle, and the probability of being in better condition when the complete vehicle is sent on the road is much greater than when repairs are made under adverse conditions of varying character, such as are often encountered when an emergency of such a type arises.

Judging from my observation, the question resolves itself into an investment of money for a complete equipment or a reserve unit, and in any operation, no matter of what type, I have studied, an opportunity has always been found to employ with profit certain spare units.

If for any reason a vehicle has to come in for a general overhaul, it certainly is not necessary to overhaul a unit that has been lately installed. An examination of it by the foreman or the responsible person in the repair organization will reveal its condition, and this should prevent a duplication of work. Proper field organizations, clothed with sufficient authority to handle emergency matters, are all that is necessary to overcome the headquarters organization's being "driven to distraction."

It should be the aim of every operator to get the greatest possible mileage out of any given class of vehicle. The setting of minimum mileage is of a decided advantage. Frankly, however, I am unable to understand how an operator can obtain 50,000 miles from a 3½-ton truck before it goes into the shop, for in our operation it would take 4 or 5 years' time to cover this mileage, and I have not been able to discover that, in any of the designs upon the market today, the engine cylinder-bore, its pistons, rings or the majority of its other component parts will wear satisfactorily and give uniform, economical service if permitted to stay on the road for such a period of time; particularly when the vehicle is away from a central-garage operation and not under the supervision of a skilled mechanic.

The question of carrying stock at central garages is of interest to all where shops are operated. To my mind, it is necessary to carry stock if excessive delays are to be avoided. That delays are being encountered by the majority of vehicle operators has been, I believe, clearly brought out, for it seems that all agree that a simplification of nomenclature is necessary. Where this occurs in any shop, it results in mechanics being transferred from one job to another, which results

in unsatisfactory workmanship and rapidly mounting labor costs, together with a delay in operation. Labor costs and workmanship are important in any operation.

In some operations where off seasons are encountered, due to climatic conditions, or to a falling off from peak delivery seasons, delay in production is not so important.

To handle economically a force of mechanics of any size, however, it is necessary to carry stock of some description. To prevent a duplication of stock and the carrying of an excessive inventory, the stock should be carefully cataloged and carried on a systematic maximum and minimum basis.

MUNICIPAL DEBT

THE percentage of public-debt increase in some American cities recently has been extremely high. Detroit led all the rest, her debt rising from $22,000,000 in 1917 to $110,400,000 in 1922, an increase of 400 per cent. To Grand Rapids, Mich., went the doubtful distinction of second honor, her percentage of increase being 225.9, or from $2,200,000 to $7,300,000. Other big increases noted during the 5 years included the following: Chicago, 122.0 per cent; San Francisco, 62.7 per cent; Milwaukee, 75.0 per cent; Minneapolis, 73.1 per cent; Indianapolis 99.6 per cent; St. Paul, Minn., 52.9 per cent; Camden, N. J., 56.7 per cent; Norfolk, Va., 182.1 per cent; Rochester, N. Y., 56.7 per cent; New Haven, Conn., 91.1 per cent; Flint, Mich., 152.7 per cent; Yonkers, N. Y., 51.5 per cent; Denver, 205.6 per cent; Omaha, Neb., 53.9 per cent; Youngstown, Ohio, 113.5 per cent; Akron, Ohio, 141.8 per cent; Reading, Pa., 52.6 per cent and Jersey City, N. J., 64.8 per cent.

New York City, whose $1,085,000,000 bonded debt is about one-tenth of all the local and State indebtedness in the United States, increased her public debt by only 6.7 per cent during the 5 years. St. Louis reduced her public debt by 30 per cent. Other reductions included those of Boston, 1.2 per cent; New Orleans, 2.5 per cent; Seattle, Wash., 7.2 per cent; Spokane, Wash., 27.8 per cent; Oakland, Cal., 72.8 per cent; Albany, N. Y., 2.6 per cent; Providence, R. I., 7.9 per cent; Trenton, N. J., 4.3 per cent; Worcester, Mass., 12.7 per cent; and Cambridge, Mass., 10.8 per cent.

In New York City in 1922 the gross bonded debt of the city was 12.2 per cent of the estimated true value of all the property in the city subject to general taxation, the Federal Trade Commission asserts. In Portland, Ore., the percentage was 11.5; Norfolk, Va., 10.0; Cincinnati, 9.3; Kansas City, Kan., 9.4; Chicago, 1.5; Philadelphia, 6.4; Detroit, 5.7; Cleveland, 4.6; and St. Louis, 0.7

The bonded debt of all cities in the United States rose, it is estimated, from $1,600,000,000 to $1,750,000,000 during the 5-year period ended with 1922. In such event, the taxpayers are mulcted from $7,000,000 to $100,000,000 more in taxes annually to provide funds for paying the increased interest charges. Such is the annual interest cost of the increase in city debt over the 5-year period. And, as communities are still increasing their debt to buy more improvements, the taxpayers, or, rather, the voters, apparently think that the increase is worthwhile. And in the meantime, thanks to an effective budget system the indebtedness of the Federal Government has fallen.—W. P. Helm, Jr., in *The Budget.*

STATUS OF THE INTER-ALLY DEBTS

THE conclusion is reached in a study recently completed by the Bankers Trust Co. of New York City in anticipation of the meeting that may be held in the near future in Paris or London to discuss plans for adjusting the inter-Ally debts, that the total of the inter-nation loans on Armistice Day was $21,599,717,000. Post-armistice loans aggregate about $7,500,000,000, bringing the grand total as of today up to about $29,100,000,000. Of the post-armistice loans it is estimated that upward of $4,000,000,000 represents simply accrued unpaid interest. Of the remainder about $1,500,000,000 was loaned in compliance with pre-armistice agreements and to a considerable sum represents the value of surplus war materials sold on credit; while the sum of around $2,000,000,000 is made up almost without exception of loans for relief and reconstruction purposes.

At the date of the armistice, according to the Bankers Trust Co.'s estimate, our loans totaled $7,077,115,000. When all loans had ceased on September 28, 1920, the total had reached $9,466,283,000. Thus in a period of two years of peace the loans had increased by the great sum of $2,389,-168,000. Of this amount $295,467,000 represented accrued interest; therefore, the actual increase was about $2,000,-000,000. About one-half of this amount seems to have gone to clear up war accounts. The balance and more than another $1,000,000,000 obtained from other sources of income appear to have been spent by foreign governments in the United States during these 2 years for food and other supplies.—*Economic World.*

NEW YORK CITY IN THE YEAR 2000

IT has been suggested that New York City, when it reaches 28,000,000 people, as is predicted it will in the year 2000, will be tremendously congested. Why should it be? If you were to take 28,000,000 people and spread them over the region, the average density would be only eight or nine people to an acre. To those who suggest that it is too late to plan New York City I would point out that in the year 1900 there were nearly 1,000,000 fewer houses than there were in 1920.—Thomas Adams, general director of the New York Regional Plan.

HIGH COMPRESSION-RATIOS AND FUEL

IT is a well-known fact that the present system of motor-vehicle taxation in Great Britain has led to the production of engines having very high compression-ratios, in order that with a given cylinder-bore a higher power may be obtained under maximum conditions, with a consequence that many thousands of engines are on the road which cannot be operated efficiently unless working with fuels that will not detonate or preignite at the compression for which they are designed. The value of a fuel is no longer to be measured by the specific gravity, the boiling-point or the Engler curve, but the factor of its ability to withstand compression, or the toluene number, must receive consideration. Thus, an engine having a low compression-ratio, with the cylinder space designed to give little turbulence, that is, a thermally inefficient engine, may run equally well on a wide range of fuels, the power output being practically proportional to the heat value of the fuel employed to which has been added the latent-heat of evaporation, but a high-compression engine on one fuel may have to be run with retarded ignition and partly closed throttle at the very moment when the maximum power is required, whereas with another fuel a full-open throttle and an advanced ignition may be employed not only with a great gain in power and thermal efficiency, but also with a great reduction in the tendency to the burning-out of valves and the pitting of valve-seats.

The designer may look to using compression-ratios up to about 6½ or 7 to 1 with a knowledge that the gain in the efficiency will increase with the increased compression. The work that has been done further carries with it the implication that in any given engine the greater the degree of turbulence obtainable, the higher the compression that may be used; that the more central is the position from which the ignition starts, the cooler the exhaust-valve and the piston top can be kept; and that, where the ignition cannot be central, it should at least be placed so that the combustion does not progress toward pockets containing heated exhaust-valves. To the fuel industry it points the way to the provision of a fuel having a standard ability to withstand compression. It is obvious that companies possessing numerous sources of supplies, all differing in their chemical nature and consequently in their ability to withstand compression, can mix the various fuels so as to give a standard compression, whereas those less favorably situated have to add aromatics, such as motor benzol, to bring their products to a toluene number that may become regarded as a standard to be expected by the engine designer.

The physical characteristics of a fuel which are not of great importance in a single-cylinder engine become of the greatest importance when more cylinders come into question, for the problem of distribution from the carbureter to the cylinder is one of great moment and one that is very considerably influenced by the volatility over the whole range of the fuel employed. It is highly probable that this problem can be better attacked from the engineering than from the chemical side, and that investigation is called for which will lead to such distributing systems as will enable all types of fuel otherwise suitable to be freely used for motor purposes. The growing production of cracked fuels makes it very desirable that the work hitherto carried out on the usual constituents of normal straight-run gasolines should be extended to those unsaturated bodies that are found in large quantities in even well-refined cracked spirit. Some little work has been done on this aspect of the subject, but the connection between the chemical constitution and the behavior in the engine is nothing like so complete as in the case of the better known and more studied aromatics, naphthenes and paraffins.—From presidential address of Dr. W. R. Ormandy before the Institution of Automobile Engineers.

SILVER HOARDING IN INDIA

IT is estimated that India has absorbed nearly 32 per cent of the world's silver production since 1890. In 33 years India's excess of imports over exports of silver has totaled 1,963,000,000 fine oz. or about 60,000,000 fine oz. per year. Almost all of this has gone into hiding. Experts estimate that the average Hindu woman carries nearly 12 oz. of silver on her person, so that India is a veritable treasure house of unused and idle wealth. The chief economic reason for hoarding in India has disappeared with the present scientific Government control over grain exports, which aims to release just enough Indian grain for export to keep up the price and not discourage production but not enough to cause scarcity or famine in case of crop failure. Silver hoarding was also resorted to in the past to evade exorbitant taxation, but with present taxes estimated at only 6 rupees out of a net income of 75 rupees, this reason no longer exists. Hoarding continues, therefore, mainly as an age-old habit and its existence is an economic blight on India. Were the silver now in hiding in India put to constructive use there would be sufficient to buy all the pumps and the steel plows and to build all the sugar centrals and all the textile factories necessary to put India on a far different economic plane than the country now occupies. The greatest need of India is the constructive use of its great amount of capital that is dormant at the present time.—F. R. Eldridge in *Commerce Reports*.

TRIALS OF THE MOTORSHIP SILURIAN

RECENTLY the motorship Silurian, an 11,000-ton vessel, built by the Blythswood Shipbuilding Co., Ltd., of Scotstoun, Glasgow, ran her official trials on the Clyde. The Silurian is 430 ft. long by 57 ft. beam and 33 ft. 2 in. molded depth, with a designed speed of 10.5 knots. The vessel is fitted with two six-cylinder Beardmore Tosi oil engines, having cylinders of 620-mm. (24½-in.) bore by 975-mm. (38⅜-in.) stroke. The trials lasted for 6 hr., and the vessel maintained an average speed of 11.3 knots, the pair of engines developing an average of 3300 i. hp. at 126 r.p.m. The fuel oil consumed during the trials was 6250 lb., or 0.315 lb. per i. hp. for all purposes. This corresponds to 11.15 tons of fuel per 24-hr. day. The average pressures recorded were as follows: blast pressure, 950 lb. per sq. in.; lubricating oil, 11 lb. per sq. in.; cooling-water to jackets, 18 lb. per sq. in.; cooling-water to pistons, 15 lb. per sq. in. The discharge temperature of the piston cooling-water was 125 deg. fahr., that of the cylinder-head cooling-water was 120 deg. fahr. During the trials all lighting, heating and engine-room auxiliary machinery was in operation, the average electrical load being 48.4 kw. On a measured mile of the test course, with the engines developing 3800 i. hp. at 130 r.p.m. a mean speed of 11.75 knots was obtained.—*Engineering* (London).

STEERING AUTOMOBILES MORE EASILY

IN my paper Steering-Gear Analyses,[1] I laid some stress on the fact that "road shock" or "wheel whip" of the steering-wheel is a very detrimental feature that is found in too many of the cars of today. In this paper it was stated that only two ways exist by which to eliminate this detrimental effect: one, purposely to introduce enough friction in the steering-knuckles and linkage to damp out the shocks, with a steering-gear that has reversible characteristics; the other, to use a steering-gear that has reversible characteristics, together with the elimination of as much friction in the remainder of the system as is possible.

It should be evident to all engineers that the selection of the latter method will produce steering results that are very much easier for the driver. In fact, balloon tires steer so much harder than do high-pressure cord-tires that the easier steering secured by use of the second method referred to is most necessary if satisfactory steering results are to be attained. Further, wheel whip rapidly is becoming almost as objectionable as "shimmy." It is being talked about more and more because driver-owners are more critical and conscious of it.

Recent experiments with a number of well-known cars make me willing to modify my statement partly, that wheel whip can be eliminated and that the easiest steering can be secured by the use of steering-gears which have irreversible characteristics, together with the elimination of as much friction as possible in the knuckles and in the linkage. It is my opinion that the use of anti-friction thrust-bearings in the steering-knuckles is one source of much wheel-whip and shimmy trouble. The use of the old plain thrust-washers will eliminate these tendencies and the finest of steering effects can be secured at the same time. Surprisingly easy steering can be secured in this way but only with a very careful study of the proper reduction ratio in conjunction with the helix ratio or pitch of the thread or the worm in the steering-gear itself. The use of the old plain thrust-washer introduces a damping effect nearest the point where wheel-whip and shimmy effects are produced; namely, at the contact of the tire with the road. In fact, one prominent manufacturer introduces a miniature disc-clutch in place of the plain thrust-washer. The added friction of such devices can be overcome easily by giving careful attention to the elimination of unnecessary friction back of these bearings, and by use of a proper reduction ratio in the steering-gear. These devices also eliminate the rapid reversal of forces that are otherwise set up in the linkage and the gear and thereby ease up the loads that these parts have to carry. Bearing in mind what has just been said, I still maintain that steering-linkage friction must be lessened and that the overall efficiency of steering-gears will have to be increased to keep pace with the rapidly increasing demands of the public for easier steering.—F. F. Chandler.

[1] See THE JOURNAL, June, 1924, p. 585.

ELECTRIC-POWER DEVELOPMENT

WE are really only just stepping over the threshold into the great domain of electricity. Electrical development is still in its earliest stages. Giant power developed to its full capacity is as yet an achievement that is unthinkable. One of the most spectacular of our dreams for the future of this Country is concerned with the possibilities that electricity offers in its development. Super-power is the big business idea applied to electrical production. It comprises the eventual linking of all the electric power in North America into one vast unit, gridironing the Country with lines that can be tapped to supply sections heretofore out of reach of power. This means the opening up of new territory and the development of manufacturing interests in locations better suited to production because of their natural resources. Electric power has always blazed the trail of better development. Cheap, adequate and dependable power is vital to every progressive interest of the Country. Railroads are turning toward electrification, farms and villages are growing users of power. It tends toward higher ethical standards, increases the productivity of individual effort and makes it possible to apply mechanical methods to routine performance. It is the application of power to the problems of living which has made events march so rapidly during the last decade, and it is safe to predict that before this century closes the world will have entered into a new era and electricity will be the motivating influence that accomplishes every commonplace as well as major action of our lives.

At the present time, only four gaps, with a total of about 25 miles, occur in the inter-connected transmission system along the Pacific coast from Canada to Mexico, which comprises a distance of about 1400 miles. Gradually this system will be connected through Idaho, Montana, Utah, Colorado and Arizona, and will comprise a circuit of over 3000 miles. Within recent months, transmission links have been completed in the Middle West so that power can be transmitted from St. Paul to Chicago, Chicago to Indianapolis, Indianapolis to Cincinnati, Cincinnati to Louisville, Louisville to Nashville, Nashville to Birmingham and Birmingham to Atlanta, routing it through the various power-systems.—O. D. Foster in *Trade Winds*.

FIRST LARGE DIESEL-ENGINE PASSENGER LINER

THE launching by the Fairfield Shipbuilding & Engineering Co., Glasgow, of the quadruple screw motor passenger ship Aorangi is of much more than passing interest, as marking what undoubtedly promises to be the commencement of a new epoch in the history of marine engineering. This vessel will rank with the finest afloat. The length is 600 ft. by 72 ft. broad and 46 ft. 6 in. in depth to the lowest weather deck. Accommodations will be provided for 440 first-class and 300 second-class passengers, along with a complement of 330 officers and crew. A speed of 18 knots is anticipated. The adoption of internal-combustion machinery has facilitated the provision of large and spacious reception rooms, cafes and the like in keeping with the latest requirements of first-class passenger service.

Chief interest, as marking a distinct and bold departure from previous practice, centers in the propelling machinery. Each of the four main engines has six working cylinders of 27½-in. diameter by 39-in. stroke, and develops 3250 b. hp. at 135 r.p.m. When the ship is in service she will be the highest-powered marine Diesel engine afloat. The design has been due to collaboration between the builders and their licensors, Messrs. Sulzer, of Winterthur, Switzerland.

The service of the ship will be between Australia and Canada. The consumption of fuel oil as compared with that of a steamer with oil-fired boilers will be much less than a half, and the economy so effected should go far to popularize this class of vessel among progressive shipowners.—*Engineering* (London).

Applicants *Qualified*

The following applicants have qualified for admission to the Society between Sept. 10 and Oct. 10, 1924. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff) Affiliate; (S M) Service Member; (F M) Foreign Member; (E S) Enrolled Student.

ALLEMAN, NORVILLE JAMES (E S) test assistant at fatigue of metals, University of Illinois, Urbana, Ill., (mail) 506 South Fourth Street, *Champaign, Ill.*

ALLEN, GERALD H. (M) president, Allen Electric Mfg. Co., 2055 Lafayette Boulevard, *Detroit.*

ANDERSON, JOSEPH A. (J) inspection foreman, A. C. Spark Plug Co., *Flint, Mich.*, (mail) 309 West First Street.

ARNOLD, B. W. (A) manager of motorcoach department, Chicago, North Shore & Milwaukee Railroad, Chicago, (mail) 407 Security Building, *Milwaukee.*

BAER, BANKARD F. (A) instructor, Camp Holabird, Md., (mail) *Raspeburg, Md.*

BENSON, ALFRED D. (E S) student, Ohio State University, *Columbus, Ohio,* (mail) 47 12th Avenue.

BERGER, F. LESLIE (M) engineer, J. G. Brill Co., *Philadelphia,* (mail) 5402 Chester Avenue.

BLANK, HARRY MADISON (E S) student, Ohio State University, *Columbus, Ohio,* (mail) 194 East 11th Avenue.

BOUKARD, SAM L. (A) salesman, Pacific Nash Motor Co., *San Francisco,* (mail) 1437 Francisco Street.

BRANNIGAN, JOHN F. (J) draftsman, 3329 North Gratz Street, *Philadelphia.*

BUCKLAND, L. J. (A) general manager, *Ford Dealers News,* New York City, (mail) 174 25th Street, *Jackson Heights, N. Y.*

BUTLER, HARRY A. (M) superintendent, Autocar Co., Ardmore, Pa., (mail) 61 Bellmead Avenue, Upper Darby Branch, *Philadelphia.*

CONNOR, KIRKE W. (A) secretary, director of sales, technical research, Ditzler Color Co., 40 Baltimore Avenue, West, *Detroit.*

DEGLER, HOWARD E. (E S) student, University of Illinois, *Urbana, Ill.*, (mail) 212 West Oregon Street.

EASTMAN, E. H. (J) assistant chief inspector, Benjamin Electric Mfg. Co., 120 South Sangamon Street, *Chicago.*

ELLIOTT, BELDON GORDNIER (E S) student, Clarkson School of Technology, *Potsdam, N. Y.*, (mail) 8 Garden Street.

ELY, NATHANIEL (E S) student, University of Michigan, *Ann Arbor, Mich.*, (mail) 620 South State Street.

EWEND, WALTER HAMILTON (E S) student in mechanical engineering, University of Illinois, *Urbana, Ill.*, (mail) 1101 West Springfield Avenue.

GLASS, JOSEPH A. (A) service manager, C. J. Siors Motors Co., Baum Boulevard at Beatty Street, *Pittsburgh.*

GOESELE, GUSTAVE A. (M) mechanical engineer, International Motor Co., New Brunswick, N. J., (mail) 925 Hillside Avenue, *Plainfield, N. J.*

GOODFRIEND, IRVING F. (J) experimental assistant, International Motor Co., *Plainfield, N. J.*, (mail) 317 Clinton Avenue.

GRAHN, RAY FREDERICK (E S) department of gas and electricity, *Chicago,* (mail) 827 Newport Avenue.

GREEN, MAURICE W. (J) junior aeronautical engineer, National Advisory Committee for Aeronautics, Langley Field, *Hampton, Va.*

GRIFFITH, MAX (E S) student, Ohio State University, *Columbus, Ohio,* (mail) 270 Chittenden Avenue.

GROCE, GARD D. (M) factory engineer in charge of experimental new design, Rollin Motors Co., *Cleveland,* (mail) 1003 East 147th Street.

GROSS, CHARLES (M) designing engineer, Fairbanks, Morse & Co., *Three Rivers, Mich.*, (mail) 910 Fifth Street.

HAEFNER, EARL W. (J) technical supervision, Cedar Rapids Auto Supply Co., *Cedar Rapids, Iowa.*

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HODGKINSON, ARTHUR (A) secretary and superintendent, New Haven Machine Co., New Haven, Conn., (mail) 426 Third Avenue, *West Haven, Conn.*

HODGKINSON, WALTER (A) treasurer and general manager, New Haven Machine Co., P. O. Box 933, *New Haven, Conn.*

HOLTHE, THORLEIF (A) research and designing, Aeromarine Plane & Motor Co., *Keyport, N. J.*, (mail) Cedar Street.

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JOSEPHSON, HELGI B. (E S) student in agricultural engineering, Iowa State College, *Ames, Iowa.*

KERR, STEPHEN L. (A) mechanical superintendent, Covey-Ballard Motor Co., *Salt Lake City, Utah,* (mail) 736 Third Avenue.

KOCHER, ERNEST A. (A) inspector and tester, Gruss Air Spring Co., *San Francisco,* (mail) 1650 California Street.

KOVARIK, JOSEPH MATTHEW, JR. (E S) student, Armour Institute of Technology, *Chicago,* (mail) 2305 South Homan Avenue.

KREUDER, ADOLPH H. (A) superintendent of motor transportation, Indian Renning Co., Inc., Lawrenceville, Ill., (mail) 122 North Third Street, *Vincennes, Ind.*

LAGE, C. H. (M) chief engineer, Linograph Co., *Davenport, Iowa,* (mail) 2805 Farnam Street.

LEACH, KERMIT JAMES (E S) student, Ohio State University, *Columbus, Ohio,* (mail) 1489 Hamlet Street.

LUNDGREN, CARL GUSTAV (A) salesman, National Malleable & Steel Castings Co., Cleveland, (mail) 1501 Stroh Building, *Detroit.*

LYONS, L. E. (A) Western sales manager, Spicer Mfg. Corporation, South Plainfield, N. J., (mail) 853 Book Building, *Detroit.*

MARSHALL, LEWIS K. (J) mechanical engineer, General Motors Research Corporation, *Dayton, Ohio,* (mail) 129 Rebecca Street.

MILLIKEN, S. LESTER (J) draftsman, Locomobile Co. of America, *Bridgeport, Conn.*, (mail) 91 Prospect Street.

MINCHIN, HENRY C. (A) president and general manager, New England Motor Sales Co., 23 West Putnam Avenue, *Greenwich, Conn.*

PARSONS, C. MAYNARD (J) service representative, Franklin Automobile Co., *Syracuse, N. Y.*

RAYNOLDS, JOHN F. (M) president, Paraflector Co., 830 Security Building, *Minneapolis.*

ROSS, E. R. (M) assistant chief engineer, Raybestos Co., P. O. Box E, Barnum Station, *Bridgeport, Conn.*

ROSSI, LOUIS M. (A) vice-president, Bakelite Corporation, *Perth Amboy, N. J.*

SAFFOLD, J. WEBB (A) manager and chief designer, Devices Development Co., 4400 Perkins Avenue, *Cleveland.*

SEEBURGER, WILLIAM E. (A) manager, Community Garage, *Crockett, Cal.*

SMITH, EASTMAN (J) experimental engineer, International Motor Co., *Allentown, Pa.*, (mail) 1351 Chew Street.

STAHL, J. KELVIN (E S) student, Armour Institute of Technology, *Chicago,* (mail) 1723 Granville Avenue.

STORRS, LUCIUS S. (M) president, Connecticut Co., 129 Church Street, *New Haven, Conn.*

SWIFT, SHERMAN G. (A) editor, Automobile Journal Publishing Co., Pawtucket, R. I., (mail) 5 Whelden Avenue, *East Providence, R. I.*

TIERNEY, J. W. (A) sales engineer, Electric Storage Battery Co., 140 South Dearborn Street, *Chicago.*

TINTERA, G. E. (E S) student, Armour Institute of Technology, Chicago, (mail) 2330 South 59th Avenue, *Cicero, Ill.*

VOSS, W. O. (A) 1519 South Second Street, *Evansville, Ind.*

WILLMAN, GEORGE L. (A) advertising executive, Lord & Thomas, 800 Wrigley Building, *Chicago.*

WITTICK, EUGENE CHARLES (E S) student, University of Illinois, Urbana, Ill., (mail) Illini Hall, *Champaign, Ill.*

Applicants *for* Membership

The applications for membership received between Oct. 15 and Nov. 15, 1924, are given below. The members of the Society are urged to send any pertinent information with regard to those listed which the Council should have for consideration prior to their election. It is requested that such communications from members be sent promptly.

ALLEMAN, NORVILLE JAMES, student, University of Illinois, *Urbana, Ill.*

ANDERSON, RALPH F., student, Armour Institute of Technology, *Chicago.*

BANKS, W. FOSTER, vice-president, Motor Haulage Co., Inc., *Brooklyn, N. Y.*

BARNARD, EDWARD R., mechanical engineer, Standard Oil Co. of Indiana, *Whiting, Ind.*

BARSOUM, FAWZY, automobile engineer, c/o R. L. Butler, *Toledo.*

BENJAMIN, MAX WILLIAM, student, University of Michigan, *Ann Arbor, Mich.*

BENNET, ROBERT H., sales engineer, Skinner Automotive Device Co., *Detroit.*

BLANDFORD, J. T., sales engineer, Zenith-Detroit Corporation, *Detroit.*

BODEN, ERNEST G., engineer Cleveland Automobile Co., *Cleveland.*

BOLKOVITINOFF, N. J., tractor engineer, Ostojenka, First Zachatievsky of the Peoples Commissariat of Agriculture, *Moscow, Russia.*

BONDER, FRANK M., student, Iowa State College, *Ames, Iowa.*

BRAIMBRIDGE, HENRY R., student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

BREDE, O. M., service manager and assistant sales manager, Hinkley Motors, Inc., *Detroit.*

BRISBIN, GEORGE W., superintendent of automobile fleet, American Natural Gas Co., *Pittsburgh.*

CHANDLER, D. H., mechanical engineer, 70 Lenox Avenue, *East Orange, N. J.*

CHILDS, RAYMOND FRANK, student, California Institute of Technology, *Pasadena, Cal.*

COFFEE, GARFIELD C., student, California Institute of Technology, *Pasadena, Cal.*

CORR, WILLIAM J., Courier Motors Co., *Sandusky, Ohio.*

CRAIG, ROBERT, construction engineer, *Dayton, Ohio.*

CRIPPS, ALBERT A., body engineer, Dodge Bros., *Detroit.*

CROCKARD, FRANCIS H., student, Yale University, *New Haven, Conn.*

CROW, SAMUEL S., JR., student, Tri-State College, *Angola, Ind.*

CULLEN, W. J., draftsman, Yellow Taxi Corporation, *New York City.*

CURL, L. C., general purchasing agent, Continental Motors Corporation, *Detroit.*

CURRIE, WILLIAM M., J. B. Currie & Son, *Brooklyn, N. Y.*

DEGLER, HOWARD E., student, University of Illinois, *Urbana, Ill.*

DE GIULIANI, HENRY GASTON, engineer, Solex Carburetor Co., *New York City.*

DEMAREST, CORBIN Z., student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

DENIS, J. CHARLES, draftsman, Eastern Engineering Co., Ltd., *Montreal, Que., Canada.*

DETWILER, FRANK THOMAS, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

DREISS, OTTO J., student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

DREYSTADT, NICHOLAS, maintenance manager, Cadillac Motor Car Co., *Chicago.*

EGGERS, HAROLD H., student, Armour Institute of Technology, *Chicago.*

ELLIOTT, BELDON GORDNIER, student, Clarkson School of Technology, *Potsdam, N. Y.*

EVANS, E. S., president, E. S. Evans & Co., Inc., *Detroit.*

EVANS, ERROL S., sales engineer, Standard Oil Co. of California, *San Francisco.*

EWEND, WALTER HAMILTON, student, University of Illinois, *Urbana, Ill.*

FISHER, W. D., supervisor of methods and rates, Advance-Rumely Co., *Battle Creek, Mich.*

FRANZEN, TORE, assistant chief engineer, Detroit Steel Products Co., *Detroit.*

FREED, NEWTON A., engineer, International Motor Co., *Allentown, Pa.*

GATTS, REUBEN E., draftsman, Continental Motors Corporation, *Detroit.*

GEPHART, VALENTINE, technical service and sales, Octo Co., *Seattle, Wash.*

GILLAM, WALLACE, R., chief engineer, Lambert Tire & Rubber Co., *Akron, Ohio.*

GILPIN, JAMES R., student, University of Michigan, *Ann Arbor, Mich.*

GOCKLEY, ROSCOE, student, California Institute of Technology, *Pasadena, Cal.*

GREENWOOD, WALTER RUSSELL, student, Brown University, *Providence, R. I.*

HANNA, ROBERT, student, Purdue University, *Lafayette, Ind.*

HANSA, CHARLES, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

HARMON, KENNETH A., laboratory assistant, Cadillac Motor Car Co., *Detroit.*

HARRIS, PHIL B., chief engineer, Los Angeles Railway Corporation, *Los Angeles.*

HART, FREDERICK P., student, University of Michigan, *Ann Arbor, Mich.*

HASKINS, BUTLER J., service engineer, Joseph Weidenhoff, *Chicago.*

HATOSY, F. E., superintendent of Maintenance, Motor Haulage Co., Inc., *Brooklyn, N. Y.*

HATTON, JULIAN B., salesman, Eagle-Ottawa Leather Co., *Grand Haven, Mich.*

HAYDEN, HOWARD A., student, University of Michigan, *Ann Arbor, Mich.*

HENRICHSEN, KNUT, aeronautical engineer, *Brooklyn, N. Y.*

HOELER, P. H., engineer, International Motor Co., *New York City.*

HOROWITZ, SAMUEL, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

HOUPERT, H. J., president, Houpert Machine Co., *Long Island City, N. Y.*

JOHNSON, ROBERT H., manager starting and lighting brush sales, National Carbon Co., Inc., *Cleveland.*

JOPP, FRED GILMAN, automotive writer, *Los Angeles.*

KELLER, OWEN V., student, University of Michigan, *Ann Arbor, Mich.*

KEPKE, JOHN, engineer, Engineering & Commerce Corporation, *New York City.*

KILTON, GEORGE WILLIAM, student, Brown University, *Providence, R. I.*

KNACK, HARRY FREDERICK, student, Armour Institute of Technology, *Chicago.*

KOHL, HARRY J., student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

KORNEFF, CONSTANTINE C., student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

KRYDER, GEORGE M., production engineer, Firestone Tire & Rubber Co., *Akron, Ohio.*

LANG, OTTO C., sales manager, Hydraulic Brake Co., *Detroit.*

LAREW, R. C., superintendent, Spicer Mfg. Corporation, *South Plainfield, N. J.*

LARSON, RALPH N., student, Armour Institute of Technology, *Chicago.*

LEBLOND, HAROLD R., secretary and treasurer, G. A. Schacht Motor Truck Co., *Cincinnati.*

LENGUADORO, JOSEPH A., student, Armour Institute of Technology, *Chicago.*

LITTLE, SIDNEY ORAL, student, University of Idaho, *Moscow, Idaho.*

LIVINGSTON, JOHN WARNER, student, Drexel Institute, *Philadelphia.*

LOTT, A. L., general manager, Motor Products Corporation, *Detroit.*

LOVE, RUSSELL J., student, California Institute of Technology, *Pasadena, Cal.*

LUCKER, MILLARD, B., chief engineer, Auto Specialties Mfg. Co., *St. Joseph, Mich.*

MALEY, R. C., general manager, Kankakee Truck Co., *Kankakee, Ill.*

MALITO, FRED, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

MARLOW, E. S., general factory superintendent, George W. Davis Car Co., *Richmond, Ind.*

MARTIN, HAROLD J., student, California Institute of Technology, *Pasadena, Cal.*

MASON, CLARENCE E., student, University of Illinois, *Urbana, Ill.*

MCDERMOTT, D. I., service manager, *Germantown, Philadelphia.*

MEUSHUL, LEO S., secretary and general manager, American Crusher & Machinery Corporation, *New York City.*

MITCHELL, W. LEDYARD, vice-president in charge of manufacturing, Maxwell Motor Corporation, *Highland Park, Detroit.*

MOISSELLE, LOUIS, sales supervisor, David Lupton's Sons Co., *Philadelphia.*

MULLER, JULIUS, student, University of Illinois, *Urbana, Ill.*

MUNNING, AUGUST PETER, director of department of research and development, A. P. Munning & Co., *Matawan, N. J.*

MURRAY, JOHN B., student mechanic, White Co., *Atlanta, Ga.*

NEWCOMB, LEROY, student, California Institute of Technology, *Pasadena, Cal.*

NOLL, PAUL E., student, California Institute of Technology, *Pasadena, Cal.*

NOREN, DELBERT P., student, Armour Institute of Technology, *Chicago.*

NORRGARD, EDWIN GUSTAVE, student, Armour Institute of Technology, *Chicago.*

NORRIS, WILLIAM J., student course, International Motor Co., *Allentown, Pa.*

PARKER, PERCY EDWIN, student, California Institute of Technology, *Pasadena, Cal.*

PHILLIPS, FREDERICK GEORGE, student, Armour Institute of Technology, *Chicago.*

PISER, RALPH STANLEY, student, University of Illinois, *Urbana, Ill.*

POPE, ARTHUR W., JR., research department, Waukesha Motor Co., *Waukesha, Wis.*

POWELL, CLARENCE HENRY, professor, University of Detroit, *Detroit.*

RETZLAFF, W. G., superintendent, Fruehauf Trailer Co., *Detroit.*

RING, R. M., branch manager, Fafnir Bearing Co., *New Britain, Conn.*

ROVERE, LEWIS HALWORTH, engineer, Western Union Telegraph Co., *New York City.*

SCOTT, CHARLES KENDALL, experimental department, International Motor Co., *Allentown, Pa.*

SCOTT, ERNEST H., technical editor, Chicago Automobile Trade Association, *Chicago.*

SKELLY, H. J., student, Armour Institute of Technology, *Chicago.*

SMITH, THEODORE, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

STERNER, JOHN J., chief engineer, Murphy Varnish Co., *Newark, N. J.*

STEVENSON, HARRY J., experimental engineer, General Motors of Canada, Ltd., *Oshawa, Ont., Canada.*

STOLL, OTTO E., vice-president and general manager, General Motors Truck Co., *Pontiac, Mich.*

SUMNER, JAMES W., research engineer, Emory Winship, *San Francisco.*

SWOBODA, HERMAN A., engineer, McCord Radiator & Mfg. Co., *Detroit.*

TABER, GEORGE H., JR., vice-president, Sinclair Refining Co., *New York City.*

TAYLOR, ROBERT EDWARD, student, Armour Institute of Technology, *Chicago.*

TIEL, ARTHUR D., service manager, Autocar Sales & Service Co., *Pittsburgh.*

TOBRASEN, THOMAS BERTRAM, student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

TRAVER, HAROLD G., bus engineer, International Motor Co., *Allentown, Pa.*

VEIT, FRANCIS X., student, Polytechnic Institute of Brooklyn, *Brooklyn, N. Y.*

WALLACE, GEORGE H., service manager, Chevrolet Motor Co., *Norwood, Ohio.*

WARDEN, CARL GLENN, truck foreman, California Highway Commission, *Briceburg, Cal.*

WEIDMANN, FRED A., time study, Salisbury Axle Co., *Jamestown, N. Y.*

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WILSON, K. R., manufacturer, *Buffalo.*

WILSON, PAUL R., student, University of Illinois, *Urbana, Ill.*

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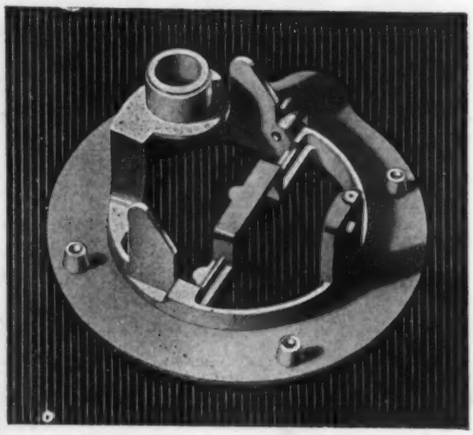

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Personal Notes of the Members

Items regarding changes in business connections, promotions, etc., are desired from the membership for insertion in these columns. This will enable members to keep their friends informed of their whereabouts and will also assist in keeping the records of the Society up to date.

Fred W. Andrew has severed his connection with the Eisemann Magneto Corporation, Brooklyn, N. Y., where he was chief engineer. His plans for the future have not been announced.

N. B. Burkness, who was formerly chief engineer for Kluber Motor Truck Co., San Francisco, has become associated with Rognon & Co., Inc., New York City.

John M. Chappius has severed his connection with the E. W. Bliss Co., Brooklyn, N. Y., where he was a mechanical draftsman. No announcement has been made of his future plans.

Glenn Coley has been appointed metallurgist of the Titusville Forge Co., Titusville, Pa. He previously held a similar position with the Timken-Detroit Axle Co., Detroit.

Thomas R. Cook, who until recently was vice-president and general manager of the Westinghouse Union Battery Co., Swissvale, Pa., has accepted a position as mechanical engineer for the Hudson Coal Co., Scranton, Pa.

Martin E. Crow has been elected treasurer of the Harter Rolled Metals Co., Goshen, Ind. Previous to this he was vice-president of the Marathon Motor Export Co., Elkhart, Ind.

William P. Culver has severed his connection with the American Autoparts Co., Detroit, where he was vice-president and sales manager. No announcement has been made of his future plans.

C. G. Dahlquist has resigned as master mechanic of the Dort Motor Car Co., Flint, Mich. His plans for the future have not been made known.

A. H. Doolittle, who until recently was vice-president of sales of the Philbrin Corporation, Kennett Square, Pa., has resigned to join the General Chemical Co., New York City, as trade investigator and statistician.

L. H. Hazard has become factory manager of the George W. Davis Motor Car Co., Richmond, Ind. He was formerly production manager of the Velie Motors Corporation, Moline, Ill.

Thomas Jackson has accepted a position as layout draftsman for the Holt Mfg. Co., Peoria, Ill. His previous business connection was with the Continental Motors Corporation, Detroit, as a detail and layout draftsman.

Joseph E. Kubacka, who was formerly body draftsman for the Fisher Body Corporation, Detroit, has accepted a similar position with the J. C. Widman Co., also of Detroit.

George A. Malkmus has severed his connection with the Rahe Auto & Tractor School, Chicago, where he was garage manager. His plans for the future have not been announced.

Harold W. Merritt, who until recently has been associated with the Duplex Engine Governor Co., Brooklyn, N. Y., as an engineer doing experimental and production work, has been appointed instructor in mechanical engineering at Cooper Union, New York City.

Edward L. Peterson has accepted a position as tool designer for the Studebaker Corporation of America, South Bend, Ind. Prior to this he was designing engineer for the Bovee Transmission Co., Chicago.

(*Concluded on p.* 4)

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PERSONAL NOTES OF THE MEMBERS
Concluded

R. S. Russell, who was formerly automobile designer for the Brooks Steam Motors, Ltd., Stratford, Ont., Canada, has become affiliated with the Reo Motor Car Co., Lansing, Mich., as experimental designer.

P. G. Sedley has joined the equipment sales force of the Lincoln Products Co., Chicago. For the last 8 years he has acted as Chicago branch factory manager for the Eisemann Magneto Corporation, Brooklyn, N. Y., and prior to that he was New York manager of the Heinze Electric Co., Lowell, Mass.

Frank W. Trabold has become associated with the Transue & Williams Steel Forging Corporation, Alliance, Ohio. Prior to making this connection he was president of the Marion Forged Products Co. and the Western Drop Forge Co., both located at Marion, Ind.

J. J. Tracy, who until recently was president of the Avenue Motor Co., Cleveland, has been made manager of the J. J. Tracy Estate, also at Cleveland.

G. P. Texada is no longer special engineer for the H. H. Franklin Mfg. Co., Syracuse, N. Y., but has accepted a position as experimental engineer with the Jordan Motor Car Co., Cleveland.

H. E. Thompson has severed his connection with the H. E. Thompson Co., Indianapolis, where he was chief engineer. No announcement has been made of his future plans.

Paul St. Elmo Webb has accepted a position with the Federal Motor Truck Co., Chicago. He was formerly assistant manager of the Diamond T Motor Car Co., also located at Chicago.

S. R. Willits, who was until recently chief engineer of the Beneke & Kropf Mfg. Co., Chicago, has been appointed general superintendent of the Universal Battery Co., also of Chicago.

"**One Engineer** never likes to do the same thing as another engineer.
"They are a proud race."
—"Line Eight" Jordan Ad, September 21, 1924

The Proud Race will be prouder [and with a most proper pride] when one and all OIL THEIR CHASSIS AS THEY OIL THEIR ENGINES—CONSTANTLY!

Blue print of your spring bolts, to Gits Brothers Mfg. Co., Chicago, will bring Oilers and Bolts that will demonstrate on your own personal car—

Gits Master-System
(GRAVITY-CAPILLARITY WICK FEED)
of Chassis OILING

CHARLES E. JOHNSON, PRESIDENT
CARL P. DAMM, VICE PRESIDENT
PAUL R. BEARDSLEY, SECRETARY & TREASURER

THE Piston RING COMPANY

Muskegon, Michigan

The close business relations which have existed between this company and the No-Leak-O Piston Ring Co. for eleven years are well known throughout the industry and the fact that we are the manufacturers of the famous No-Leak-O piston rings has been established for some time.

Beyond the actual manufacture of the rings, the two organizations functioned on an entirely individual basis, with the No-Leak-O Co. concentrating all its efforts on the grooved ring field and the Piston Ring Co. on the plain ring field.

The agreement under which we have manufactured the No-Leak-O Piston Ring has expired and being cognizant of the growing demand for oil rings, negotiations were begun several months ago looking toward the consolidation of the two companies, with the natural resulting benefits and economies inevitable in such a consolidation.

It gives us much pleasure to announce that this consolidation has been accomplished and will be in effect November 1st, 1924.

Mr. L. F. Iverson, Manager of Service Division of the Piston Ring Co., will continue in that position in which he will have general supervision of the Service Branch of the business but will devote his time principally to the Quality Plain Ring department, while the No-Leak-O and Sealdrain rings will be combined in a department with Quality Drainoil rings under the management of Mr. L. G. Matthews, Treasurer of the No-Leak-O Co., who will be assisted by Mr. John E. Norwood, Jr., son of the inventor of No-Leak-O piston rings.
This consolidation provides not only the perfect piston ring line but insures also the continued effort and attention of men entirely familiar with both the plain and oil control rings, and who are thoroughly acquainted with the requirements of the trade.

You will appreciate that this combination will effect economies in various ways, the results of which we propose to pass on to you as is possible from time to time.

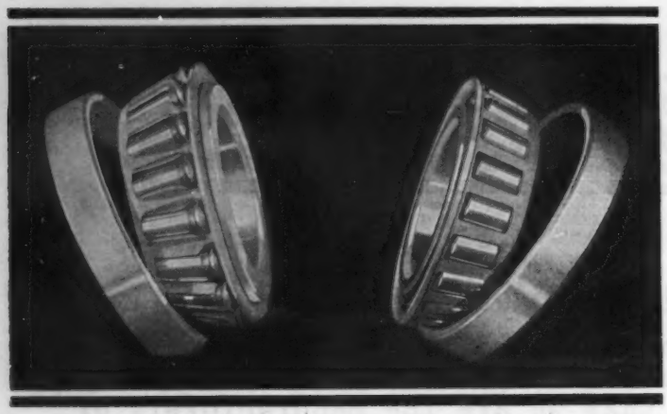
We solicit your increasing patronage and pledge you the same co-operation that has been such a factor in building up both companies.

Yours very truly,

THE PISTON RING COMPANY.

By Paul R. Beardsley

Sec. & Treas.



Put a Stop to Bearing Troubles

BOCK now offers to car and truck manufacturers a complete range of tapered roller bearings in the new series.

The extraordinary performance of these chrome nickel steel bearings with the round head rollers is a matter of record which we shall be glad to lay before you.

As standard equipment in wheels, differentials, pinions and steering pivots of many well known makes of cars, Bock Bearings give uniform satisfaction and replacements are almost unheard of.

May we send samples for testing?

THE BOCK BEARING COMPANY
TOLEDO, OHIO

BOCK
Quality TAPER ROLLER
BEARINGS

Notes and Reviews

This column, which is prepared by the Research Department, gives brief items regarding technical books and articles on automotive subjects. As a general rule, no attempt is made to give an exhaustive review, the purpose being to indicate what of special interest to the automotive industry has been published.

Le Nouveau Dirigeable Transatlantique. By R. Caillol. Published in *La Technique Moderne*, Oct. 1, 1924, p. 645; 19 illustrations.

A statement introducing this nine-page article calls attention to the fact that the construction of the ZR-3 marks a decisive advance in the technique of lighter-than-air craft, and its transatlantic flight points to the possibilities of the development of rapid transatlantic air service.

The ZR-3 has a gas capacity of 70,000 cu. m. (2,472,010 cu. ft.), a maximum length of 200 m. (656 ft.), a maximum diameter of 27.64 m. (91 ft.) and a maximum height of 31 m. (102 ft.), including the shock-absorbers on the cars. The hull, comprising a duralumin frame, an envelope and a number of gas cells, is described in detail, and data are given for the buoyancy, the speed and the cruising range of the airship.

In conclusion it is stated that, in spite of its great dimensions, the ZR-3 is not the largest dirigible built thus far. During the war two were built that surpass it in size, but the fact is emphasized that the ZR-3 is planned especially for the rapid carrying of mail and not for the transport of huge loads of explosives.

Possibilities of Trans-Ocean Air Travel Established by Flight of the ZR-3. Published in *Automotive Industries*, Oct. 23, 1924, p. 720.

This two-page article, introduced by general remarks concerning the ZR-3 and its transatlantic flight, contains a description of the ship and its equipment.

Condensation of Water from Engine Exhaust for Airship Ballasting. By Robert F. Kohr. Air Service Information Circular, Vol. 1, No. 44. Published by Chief of Air Service, City of Washington. 41 pp.; 39 illustrations.

An introductory section states that the maintenance of a constant total lift in lighter-than-air craft falls naturally into two distinct divisions: (*a*) recovery of ballast as the consumption of fuel tends to lighten the ship and (*b*) control of the temperature and thus the density of the lifting gas to compensate for changes of lift due to changes of atmospheric density or superheating of the lifting gas by solar radiation upon the envelope. It is pointed out that the problem is of great significance when helium is used as a lifting gas. In long flights both phases of the ballasting problem assume considerable importance, but of the two the first appears to be the more vital, and this paper deals only with the work on ballast-recovery apparatus.

The first part of the paper deals with general considerations, including a review of previous work, a description of two types of condenser, test-results obtained with them and the conclusions drawn. The second division of the paper reviews the theory involved in the process of obtaining water from the engine exhaust-gas, and the third part takes up the design and construction of a condenser that will meet certain given requirements.

In conclusion, some of the general points bearing on further work are assembled; these apply only to apparatus of the same general type as that exemplified by the two models discussed in this paper.

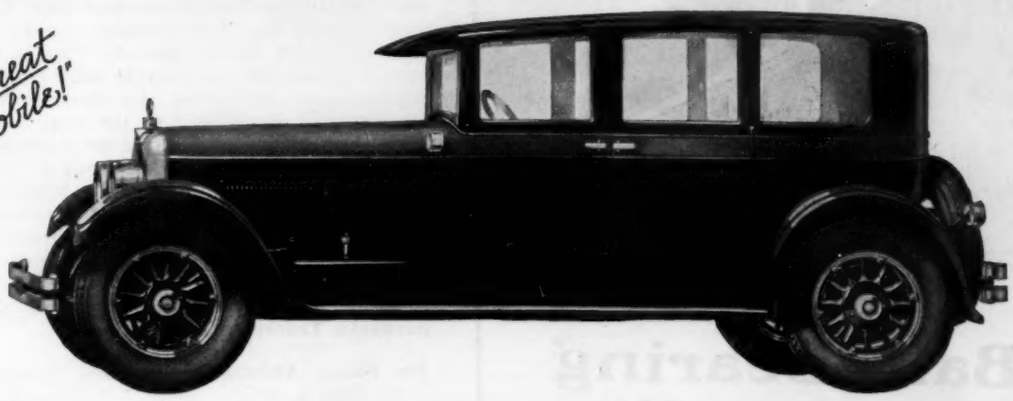
German Development of Gliders and Light Airplanes. By G. Lachmann. Published in *The Aeroplane*, Oct. 1, 1924, p. 325; 4 illustrations.

A brief account is given of a glider meeting and a light-airplane competition that took place recently in Germany.

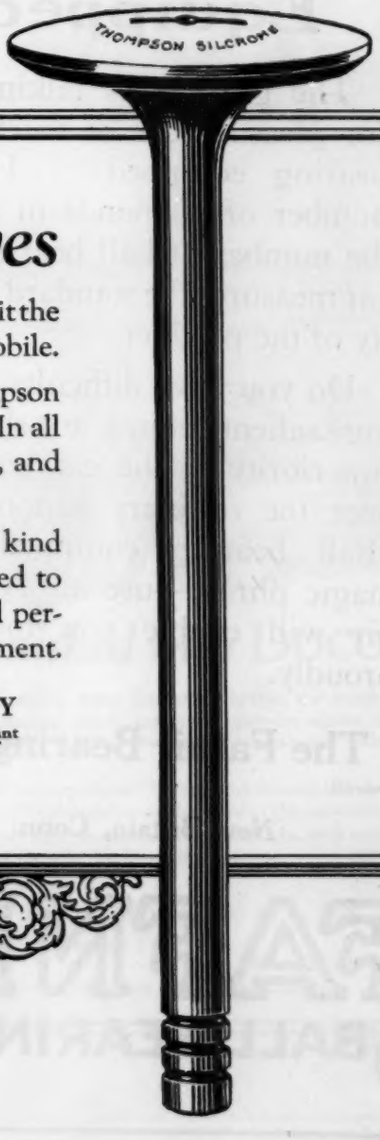
(*Continued on p. 8*)

MARMON

"It's a Great Automobile!"



The New MARMON



Thompson Silcrome Valves

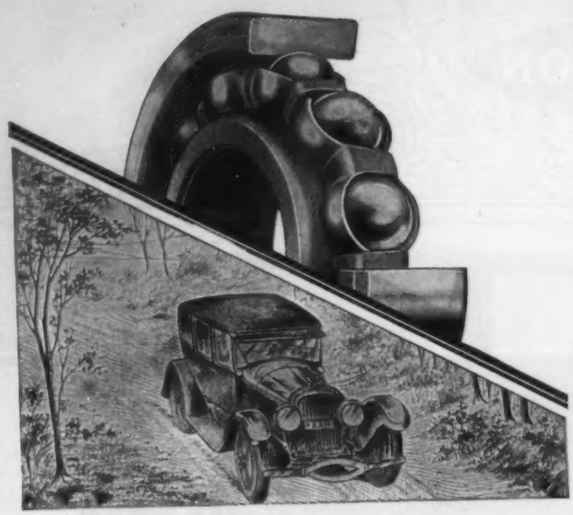
are standard equipment in this distinguished car, contributing to it the reliable valve efficiency which is essential in a high-grade automobile.

On the test block, in the sky, and on the road, Thompson Silcrome Valves have created new standards of performance. In all kinds of motors they have proved non-burning, non-warping, and exceptionally resistant to wear.

Twenty years of valve-manufacturing experience and a new kind of steel peculiarly adapted to valve service, have been combined to produce Thompson Silcrome Valves—supreme in quality and performance—indestructible—and equal to every motor requirement.

THE STEEL PRODUCTS COMPANY

Main Plant CLEVELAND [*Also manufacturers of king, shackle, and tie-rod bolts, tappets, drag links, starting cranks, and brake rod assemblies.*] Michigan Plant DETROIT



"Ball Bearing Equipped"

The great sales talking point for pleasure car or truck—"ball bearing equipped." Like the number of diamonds in a watch the number of ball bearings in a car measures the standard of quality of the product.

Do you have difficulty in finding salient points to show the superiority of the car you make over the ordinary run of cars? "Ball bearing equipped" is a magic phrase—use it. And Fafnir will enable you to use it proudly.

The Fafnir Bearing Co.

Detroit Chicago

New Britain, Conn.

FAFNIR BALL BEARINGS

NOTES AND REVIEWS

Continued

The principal features noted with regard to the gliders are (*a*) some successful flights with a perfectly tailless machine controlled by wing flaps and (*b*) tests of three machines fitted with variable wing-sections.

With regard to light airplanes, it is stated that until very recently Germany was dependent upon English engines, as it is only lately that light German engines such as the Siemens have appeared on the market. This is described as a two-cylinder Vee-type motorcycle engine with double overhead inlet and exhaust valves. Its stroke volume is 745 cc. (45.47 cu. in.), and at 3500 r.p.m. the engine develops 20 hp.; between the crankshaft and the propeller-shaft a gear is fitted which reduces the propeller speed to 1500 r.p.m. The following types of light airplane are briefly described: the Udet Kolibri which is a high-winged cantilever monoplane with wings that are divisible at their center; the Habicht, a high-winged cantilever; the Bahndebarf monoplane, the wings of which are fitted immediately above the upper part of the fuselage; and a low-winged two-seater produced by the Casparwerke Travemunde.

The Fairey Ambulance Seaplane. Published in *Flight*, Oct. 16, 1924, p. 667.

A seaplane is described which has been fitted out as an ambulance for service in British Guiana. A trip that has hitherto required 17 days will be made by the plane in a little more than 2 hr. In the present case, the importance of rapid communication is chiefly with regard to illness. White men developing fever on the plantations are in serious danger, and it is considered that the new service will result in the saving of many lives. This is a very interesting example of the serious application of flying for civil purposes.

The seaplane is of the Fairey III-D type, equipped with a 360-hp. Rolls-Royce Eagle IX engine. The machine is specially built to resist the tropical conditions, the float bottoms being covered with stainless steel and specially coated. When desired, the machine can be rapidly converted for carrying passengers or supplies.

An Investigation of the Movements of the Points of Inflection on Beams under Various Combinations of Loads. By H. A. Sutton and J. S. Newell. Air Service Information Circular, McCook Field Report, Serial No. 2324. Published by Chief of Air Service, City of Washington. 7 pp.

The results of an investigation are given, the purpose of which was to determine whether or not the location of the points of inflection on a beam changed materially under different ratios of the bending load to the axial load and different degrees of restraint at the points of support. In a summary of the results the conclusion is stressed that the points of inflection are unchanged as long as the axial load is constant and the ratio of the lateral load to the restraining moment is the same; if, however, the axial load is varied and the ratio of the lateral load to the restraining moment kept constant, the points of inflection move and the maximum moments in the span vary at a different rate from either the axial or the lateral loads. The discussion is accompanied by two tables and four diagrams.

Metals Used in World Cruiser Airplanes. By J. B. Johnson. Published in *The Iron Age*, Oct. 16, 1924, p. 994.

The most radical developments in all-metal airplanes, it is stated, are the types in which both the fuselage and the wings have been built entirely of metal. The type of construction that is used more extensively at the present time is a combination of wood and metal members. The wings are similar to the older types in that the structure is wood and the covering is doped fabric. The fuselage, however, is made of steel tubing welded at the strut points either by oxyacetylene or electric welding. This type of construction,

(*Continued on p.* 10)

THE SATURDAY EVENING POST
Velvet on Wheels
THE END OF THE MATINEE . . . a line of automobiles at the curb . . . the neighborly hum of idling motors . . . and a silent, beautiful car—waiting for your touch. to drift away with you through the twilight.
Your car, finished with DUCO, grows more lustrous with the passing of time. Its rich, slumbrous color remains unfading.
A very part of your own individuality it seems, in its soft, velvety Old Blue—or Sylvan Green—or the color combination you prefer.
Makers of fine cars are now finishing them with DUCO—its soft glow is the ultimate in good taste.
E. I. DU PONT DE NEMOURS & CO., INC.
Chemical Products Division
PARLIN, N. J.
DUCO
DU PONT
New Cars
Refinishing
Other Uses
Look for the DUCO Nameplate

Miniature reproduction of color advertisement appearing in the November 8th issue of The Saturday Evening Post.

"Is this car finished with DUCO?"

ALONG with the usual questions about four wheel brakes, the number of cylinders and other mechanical details, comes the up-to-the-minute one—"Is this car finished with DUCO?" And no evasive or "just-as-good" talk will satisfy the prospect!

When a dealer says "this is a Duco type finish" he is only weakening his case and strengthening the hold that DUCO already has on the mind of the car-wise buyer.

The recent Closed Car Shows have shown that the whole industry is swinging to this finish, and the demand for it is fast becoming universal.

DUCO finished cars are easier to sell!

E. I. DU PONT DE NEMOURS & CO., Inc.

Chemical Products Division:

Parlin, N. J. **Flint, Mich.**

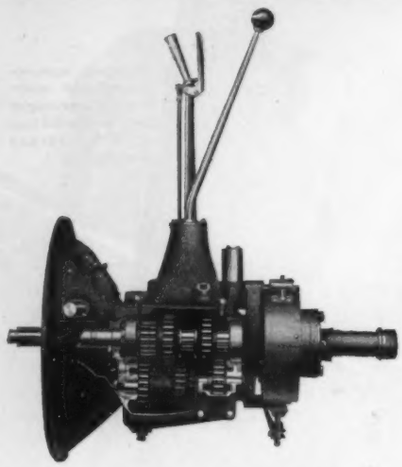
Canadian Distributors: **Flint Varnish & Color Works, Toronto**

Duco is factory standard on: Hupmobile (all models); Jewett (all models except Standard Brougham); Maxwell (all models); Marmon (all models); Oakland (all models); Oldsmobile (all models); Buick (all Sport Models); Cadillac (Roadster); Chevrolet (all de Luxe Models); Gardner (Special Touring Models); Meteor Motor Car Co. (Standard); Moon (all series "A" 1925 models); Nash (Special Six Touring, Special Six Sedan, Advanced Six Sedan).

* * * *

Over 200 Duco Refinishing Stations have already been established throughout the country. Training schools are being organized as rapidly as possible.

DU PONT DUCO



TRANSMISSIONS and Universal Joints, are two very important units, on an automobile or truck.

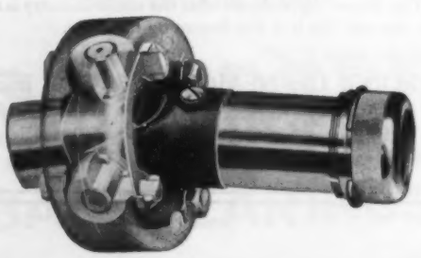
The best source of supply is none too good.

Mechanics Machine Co. with thirty-four years of continuous manufacturing experience is at your service.

Your inquiries respectfully solicited.

Mechanics Machine Co.
Rockford, Ill.
Plant and Gen. Office

C. A. S. Engineering Co.
4222 Woodward Ave.,
Detroit, Mich.
Sales Representatives



NOTES AND REVIEWS
Continued

the author states, has been adopted as standard by the Army Air Service and was used on the Douglas world cruiser airplanes. The construction of the fuselages for these airplanes is described and illustrated in this article, and some consideration is given to the materials used in the structural members of the fuselage.

In conclusion the author gives his opinion that undoubtedly the future airplane will be built entirely of metal on account of its uniformity and permanency, and that the structure will probably be a combination of alloy-steel and heat-treated aluminum alloy, developed on the basis of the lightest weight for the maximum strength and stiffness.

Fuel Economy in Flight. By H. T. Tizard. Published in *The Journal of the Royal Aeronautical Society*, October, 1924, p. 604.

Fuel consumption in flight, the author states, is dependent on three main factors, namely, the aerodynamic efficiency of the airplane, the thermal efficiency of the engine and the efficiency of navigation, which entails a study of the most advantageous height, speed and direction of flight under any conditions of wind. This paper is devoted to fairly general considerations of the problem, with particular reference to the commercial airplane. It is pointed out that distinct advances have been made in the direction of fuel economy in flight since the war period but that even now the weight of fuel carried in a commercial machine operating over the comparatively short London-Paris route of 230 miles and capable of a cruising speed of 100 m.p.h. is approximately half the full paying load carried, so that a reduction of the fuel load by 40 per cent, which is claimed to be by no means outside the range of possibilities, would increase the paying load by 20 per cent, other things being equal.

After mentioning briefly previous experimental work on this topic, the author divides the problem of fuel economy in flight into two parts: (*a*) the principles governing the most economical use of an airplane in flight, having regard to weather conditions, and (*b*) the principles underlying the design of airplanes to secure the maximum efficiency of operation. In this paper the chief emphasis is placed on the first part, although it is pointed out that its consideration leads on naturally to a review of some of the more important scientific questions affecting economical design.

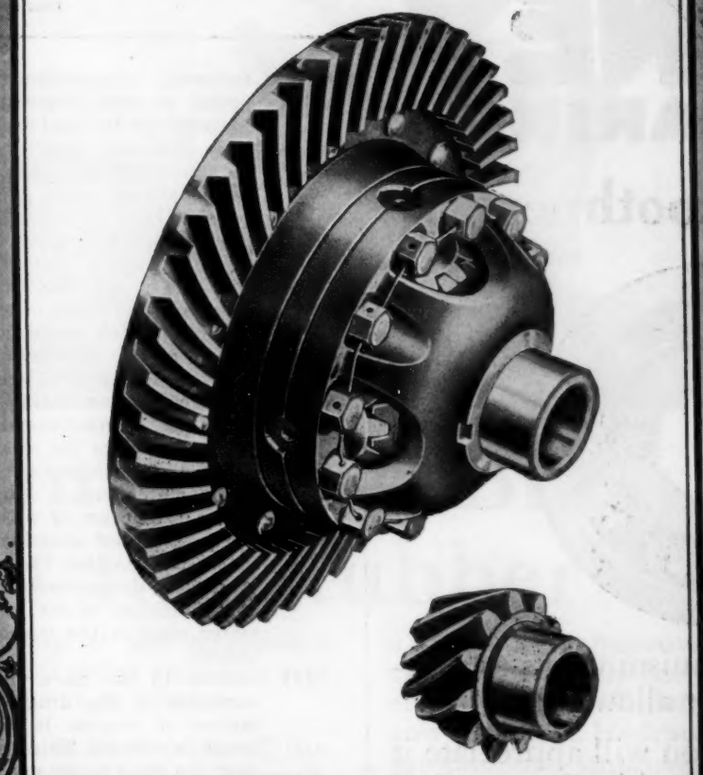
Important points brought out in the paper include the following:

(1) The range of any given airplane in still air depends only on the indicated air-speed and is independent of height. This conclusion is independent of any assumption as to the decrease in the maximum engine-power with the height. The variation of the engine power with the height affects the performance of an airplane but not its range at any indicated air-speed

(2) By flying high on a calm day, time but not fuel can be saved if there is no wind

(3) The relation between the rate of fuel consumption of the engine and the speed of an airplane is so intimately bound up with the characteristics of the airplane that at first sight it might seem a matter only to be discussed in relation to a particular engine and airplane; but here again general considerations help in getting some idea of what to expect. Considerable importance is sometimes attached to the results of observations of fuel consumption, at various speeds, of a throttled engine coupled to a dynamometer, but for many reasons it is doubtful whether such results can be applied with any confidence when estimating the fuel consumption of a throttled engine in flight. It would probably be of more value if the

(*Continued on p.* 12)



BROWN-LIPE-CHAPIN

DIFFERENTIALS — BEVEL DRIVE GEARS

WHEN it is remembered how important a good differential is to uninterrupted motor car performance, it is easy to understand why so many automotive manufacturers insist on Brown-Lipe-Chapin units for the rear axle assembly.

Manufactured at Syracuse, N. Y.

BROWN-LIPE-CHAPIN DIFFERENTIAL GEARS FOR AUTOMOBILES SYRACUSE, N.Y.

GURNEY BALL BEARINGS

—for Smoothness

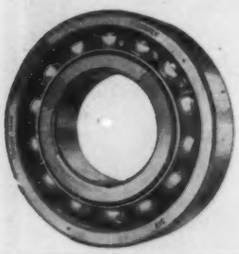
Your motor car mechanism wants to operate smoothly—why not allow it?

Engine and transmission will appreciate it when you equip them with Gurney Ball Bearings. They will show their appreciation in added years of useful life as well as in better work now.

The immediate result of Gurney Ball Bearing Equipment is smooth, frictionless operation. The final outcome is just so many years added to the serviceability of the entire mechanism.

Fine design, superior steel, careful inspection, years of experience in Bearing Engineering—that's the Gurney platform in brief.

Let us tell you why Gurney Ball Bearings safely carry greater loads than other bearings of equal size.



GURNEY BALL BEARINGS

Marlin-Rockwell Corp.
JAMESTOWN, N. Y.

NOTES AND REVIEWS

Continued

following observations were taken: first, the actual gasoline consumption, without special adjustment of the carbureter, at (*a*) 90 per cent of the maximum speed and 85 per cent of the maximum torque and (*b*) at 70 per cent of the maximum speed and 70 per cent torque; and second, the *minimum* consumption under the same conditions, observed by reducing the gasoline supply by adjusting the "altitude" control. The range of speed and torque corresponds to the normal range in level flight of a commercial airplane, and the observation would not only give a truer indication of the minimum fuel-consumption to be expected in flight but would also test the accuracy of the carbureter setting and would give a valuable check on the mechanical efficiency of the engine. But apart from the question of the accuracy of the carbureter adjustment, there is a further more fundamental reason why bench figures for the fuel consumption of a throttled engine cannot be applied without question to flight conditions. To do so implies that the characteristics of an airplane as a dynamometer correspond exactly to the characteristics of the particular kind of dynamometer used in the bench tests; this is obviously untrue

(4) Relative to the more important question of the variation of the drag with the speed, the first matter of interest is to estimate the maximum range in still air. This occurs at such an air-speed that the drag is the minimum, or nearly so

(5) How far it is desirable to decrease the wing area to get better economy in flight at high speeds depends upon the answer to two practical questions: (*a*) what is the highest velocity of wind which one must take into account in organizing a regular air-transport service and (*b*) what is the minimum speed over the ground at which an airplane becomes a reasonable method of transport? Indeed, the effect of the wind on the actual range of an airplane and on the weight of fuel that must be carried to complete a certain distance over the ground is so great that although calculations of the maximum range of an airplane in still air have a certain interest of their own, particularly in connection with record long flights, yet one may say that the interest is largely academic

In answering the two questions mentioned above, it is stated that (*a*) in the winter months it may be necessary to provide for fuel to contend with a wind of at least 50 m.p.h., whereas in the summer months it is necessary only to allow for a wind up to 40 m.p.h., and (*b*) the highest cruising speed must be at least 100 m.p.h.

In conclusion it is stated that it is in the directions of lowering body resistance and of developing engines of greater economy in fuel consumption that there appear to be the most immediate possibilities of a marked improvement in the economy of flight.

Flame Speed and Spark Intensity. By D. W. Randolph and F. B. Silsbee. National Advisory Committee for Aeronautics Report No. 187. Published by National Advisory Committee for Aeronautics, City of Washington. 14 pp.; 3 tables; 7 illustrations.

Experiments are described which were performed at the Bureau of Standards under the auspices of the National Advisory Committee for Aeronautics. The investigation was undertaken to determine whether or not the electrical characteristics of the igniting spark have any effect on the rapidity of flame spread in the explosive gas mixtures which it ignites. The results show very clearly that no such effect

(*Continued on p.* 14)

Remember the Brass Horn With the Rubber Bulb?

Chattering along at the desperate speed of a full 20 miles an hour, you "honked" for the right of way.

You slapped the rubber bulb of the old brass horn—one slap or punch per honk.

Now you press your finger lightly on a button—and the electric horn under the hood shrills out a warning that carries a mile.

No manufacturer would think of equipping a car with the old rubber-bulb horn today—and the day is not far distant when no manufacturer can afford *not* to equip with Lockheed Hydraulic Four-Wheel Brakes.

The whole story can be summed up in a sentence: There has never been a sound major improvement in motor car design which has not eventually enjoyed universal demand and use—and Lockheed Hydraulic Brakes *are* a fundamental improvement of major importance.

You can't escape progress—except by dying.

You can't ignore a great fundamental improvement like Lockheed Hydraulic Brakes without eventually being ignored—by public and by dealers.

Why should any manufacturer continue to penalize himself and his dealers in the face of the brilliant success of Lockheed Hydraulic Four-Wheel Brakes?

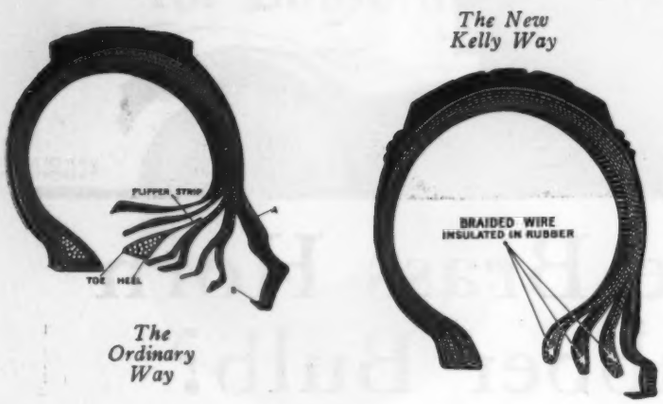
There is only one answer to that question: He shouldn't.

HYDRAULIC BRAKE COMPANY
5835 Russell Street Detroit, Michigan

LOCKHEED

Hydraulic Four Wheel Brakes

The KELLY tire with the integral bead



BY the use of an entirely new and radically different process of manufacture, used only by Kelly, the bead is formed by enclosing strips of insulated braided wire in the loops formed by the cords, which, instead of extending merely from bead to bead as in the ordinary construction, are continuous, from the beginning of the inner ply to the end of the outer. Thus the bead is actually a part of the tire from the first, instead of being set into it later and held in by adhesion.

With the new Kelly construction the cords are not cut off at the beads, but are continuous and are built in an absolutely uniform tension. Hence the tire naturally has more "give" and flexibility. The bead *cannot* break out or separate, and since there is no flipper strip to cause a stiffening of that part of the sidewall nearest the rim, a source of possible trouble is removed.

We want to emphasize the fact that the Integral Bead is not simply a minor improvement that gives us something to talk about. It is a real innovation in tire building. Not only does it strengthen what has been a more or less vulnerable point, but it makes the whole tire more flexible and adds to its life.

Kelly-Springfield Tire Co.
250 West 57th St., New York

NOTES AND REVIEWS
Continued

exists. The flame velocity in carbon-monoxide-oxygen, acetylene-oxygen, and gasoline-air mixtures was found to be unaffected by changes in spark intensity from sparks which were barely able to ignite the mixture up to intense condenser discharge sparks having 50 times this energy.

A Short Method of Calculating Torsional Stresses in an Airplane Fuselage. By John E. Younger. National Advisory Committee for Aeronautics Technical Note No. 203. Published by National Advisory Committee for Aeronautics, City of Washington. 30 pp.; 10 illustrations.

This report deals with an investigation carried out in the Civil Engineering Laboratory of the University of California, to determine the accuracy of existing methods of computing stresses in an airplane fuselage when subjected to torsion, and to derive a simple approximate formula for the rapid calculation of these stresses. The formula is derived by using the customary least-work equation and considering each bay separately. The errors due to assumptions in regard to members, sections, fittings, modulus of elasticity and the like are made compensating as far as possible. The assumption is made that the wooden members, i.e., the longerons and the struts, may be neglected. It is further assumed that the wires in both directions in the side trusses are equal in size and length, that the wires in the top plane are of the same size and length as those in the bottom plane and that the fuselage is symmetrical with respect to the longitudinal axis.

In comparison with experimental results, it is shown that the derived formula gives more accurate results in this case than some existing standard formulas.

Ueber die Zerstaubung flussiger Brennstoffe. By R. Kuehn. Published in *Der Motorwagen*, Oct. 10, 1924, p. 499. Illustrated.

Apparatus used in fuel tests at the Technical High School at Danzig is described. One feature of the apparatus that receives special consideration is the nozzle for spraying the fuel. This nozzle is illustrated by a diagram that shows each part in its proper size.

Type C Engine-Driven Gear Fuel-Pumps. By H. C. Osborne. Air Service Information Circular, McCook Field Report, Serial No. 2284. Published by Chief of the Air Service, City of Washington. 30 pp.; 24 illustrations.

The following means that have been employed on aircraft for transferring fuel from the tank or tanks to the carbureter are briefly discussed: (*a*) gravity, (*b*) vacuum and gravity, (*c*) air pressure and (*d*) fuel pump. Greater power efficiency, increased speed of pump as the consumption increases, less weight, no parasite resistance, greater torque, any desired pressure and no tank pressure are mentioned as the advantages of an engine-driven fuel pump; and the importance of getting into production a reliable engine-driven fuel-pump is stressed.

Topics treated in the report are the following: history of engine-driven fuel-pump development up to the Type C pumps, history of the Type C pumps, gear pump theory, description of the C-5 pump, installation in the airplane, the gear pump in service, overhaul of the gear pump, comparison of the C-5 gear pump with other fuel pumps and miscellaneous facts concerning this type of fuel pump.

An item of special interest is found in the section on the gear-pump fuel-system, where the fuel system for a supercharged engine is discussed. The supercharger fuel system, it is stated, is like the typical fuel system with the exception that the relief valve and the pressure gage are changed, and each has an air line connected from the supercharger air duct. The relief valve and the pressure gage suitable for the supercharger system are described.

(*Continued on p.* 16)

New Departure Ball Bearings

What Is the Life of a Car?

It Is What You Make It—as These Facts Show

THERE are some points, like pistons, rings and gear teeth, that must depend upon a nice fit, proper steels and good lubrication to keep the wear down as low as possible—but at scores of other points in the chassis, it is up to the designer to decide just how much wear is to take place. If wear is to be held to a minimum, ball bearings must be on that job.

They substitute rolling contact for rubbing, sliding contact. Nothing rolls so easily, so friction-free as a ball. And when ball bearings are made as New Departure makes them, no wear occurs during the life of the mechanism they serve.

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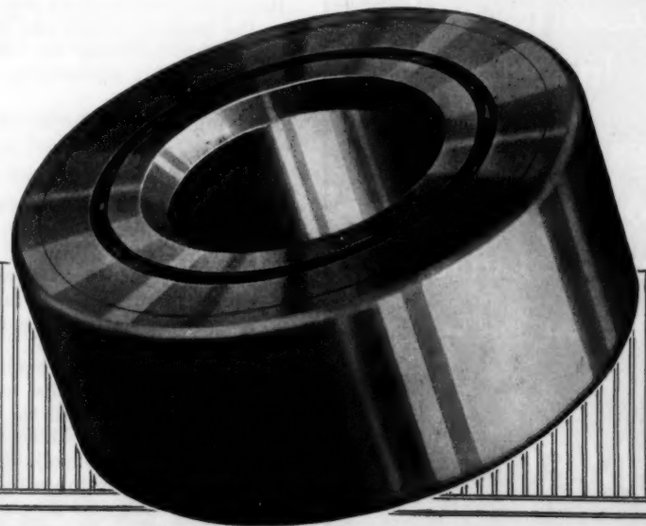

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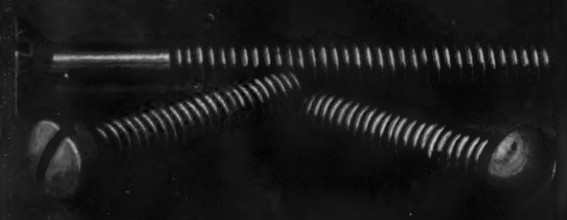

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NOTES AND REVIEWS
Continued

Correcting Horsepower Measurements to a Standard Temperature. By Stanwood W. Sparrow. National Advisory Committee for Aeronautics, City of Washington. 14 pp.

The relation between the temperature of the air at the entrance to the carbureter and the power developed by the engine is discussed. Since the primary aim is the finding of a satisfactory basis for correcting power measurements to a standard temperature, the article is limited to a consideration of the range of temperatures likely to result from changes of season, locality or altitude.

The tests upon which this report is based were made upon aviation engines in the altitude laboratory of the Bureau of Standards. From the results of over 1600 tests it is concluded that, if calculations be based on the assumption that the indicated horsepower of an engine varies inversely as the square root of the absolute temperature of the carbureter air, the values obtained will closely check experimental measurements. The extent to which this relationship would be expected from theoretical considerations is discussed, and some suggestions are given regarding its use in correcting horsepower measurements.

An interesting feature of the report is a discussion of the sources of error that may arise in this sort of work, which requires accurate and sensitive measuring apparatus and means for maintaining conditions constant while measurements are being taken.

A bibliography of 13 references adds to the interest and the usefulness of the report.

Modern Bus Needs Forced Ventilation and Increased Heat Supply. By Lewis Yorke. Published in *Automotive Industries*, Oct. 9, 1924, p. 640.

A suggestion for more adequate bus ventilation involves using the engine itself as the means of driving some form of exhaust or induction fan, preferably incorporating the fan in the engine flywheel. Thus the ventilating system, unlike the type that is dependent upon a draft induced by the motion of the bus, would be in operation whether the bus was moving or not, since bus drivers seldom stop the engine when their vehicles are in service.

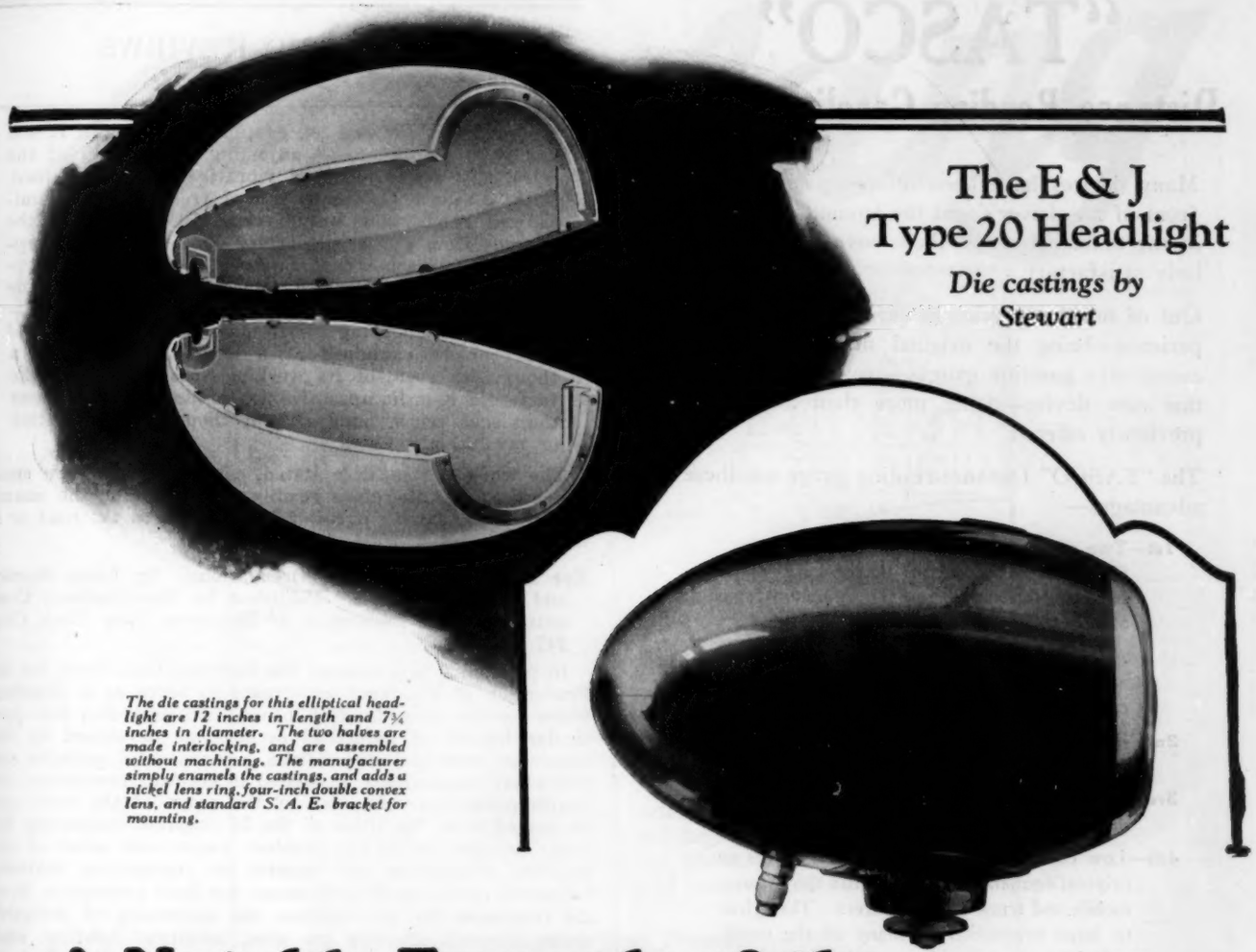
Relative to supplementing the heating systems now in use, it is pointed out that air passing through the average automobile radiator is raised from 25 to 50 deg. fahr. above its initial temperature and that this heat should be carried to the interior of the bus body if practicable means could be found for utilizing it. Several practical suggestions are offered in this connection.

Studying Moving Parts. Published in *The Motor*, Sept. 23, 1924, p. 319.

A French invention for examining oscillating mechanism at an apparently reduced speed is described as follows:

> The Guillet stroboscope consists of a vibrating wire provided with a knurled adjusting screw, by which the tension can be varied within very fine limits. On the center of this wire is hung a small contact dipping into a mercury bath, while above the wire at this point is a small electromagnet. The electromagnet is connected up to a battery in such a way that, with the contact piece carried on the wire dipping into the mercury, current flows round the windings of the electromagnet and the wire is attracted upward, so that it breaks contact, then immediately drops and so on, so long as the current continues to flow; in principle, very similar to the working of an electric bell or coil trembler.
>
> Meanwhile, the same mercury bath interrupts the current passing from the battery accumulators through the primary winding of an induction coil, from the secondary windings of which current is taken to feed

(*Continued on p.* 18)



The E & J Type 20 Headlight

Die castings by Stewart

The die castings for this elliptical headlight are 12 inches in length and 7¾ inches in diameter. The two halves are made interlocking, and are assembled without machining. The manufacturer simply enamels the castings, and adds a nickel lens ring, four-inch double convex lens, and standard S. A. E. bracket for mounting.

A Notable Example of the Possibilities of Die Casting

The die castings illustrated above which Stewart has made for the Edmonds & Jones Corporation speak eloquently of the possibilities of Stewart Die Castings for other manufacturers.

New developments in the industrial art of die casting are being made continually by this organization. Heavy pieces are now being handled easily which a short time ago it was thought impossible to die cast. Intricate parts, pieces requiring insets, threading, and special alloys can be handled at tremendous savings.

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On the dash, where the driver by a simple hand operation can see the amount of gas at any time.

Also on the tank dial showing automatically all the time (where the filling station man can see it).

2nd—Mechanically operated. No air pressure—no electricity—no chains—no liquids.

3rd—Nothing to get out of order. Guaranteed dependable for the life of the car.

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Manufacturers of Auto, Vehicle and Truck Specialties, Gasoline and Oil Gauges, Screw Machine Products, Metal Stampings, Steel Rings and Forgings.

AKRON, OHIO, U. S. A.

TASCO GAUGES

NOTES AND REVIEWS

Continued

a high frequency or Neon gas inspection lamp. It will easily be seen that, by adjusting the tension of the wire, any desired rate of vibration can be obtained, with, consequently, any required frequency of illumination. Thus, it is only necessary to switch on the current from the small battery operating the electromagnet, which keeps the wire vibrating until a frequency is obtained which coincides with that of the part under examination, which will then appear stationary. By reducing the frequency very slightly, the part can be examined at a tenth, a hundredth, a thousandth even, of its working speed, owing to the fact that it is lit up a fraction of its movement later than each tenth, hundredth or thousandth oscillation or revolution.

The whole device, it is stated, can be carried in a small suitcase and is therefore readily adaptable for the examination of the moving parts of a car either on the road or in the garage.

Eye Hazards in Industrial Occupations. By Louis Resnick and Lewis H. Carris. Published by The National Committee for the Prevention of Blindness, New York City. 247 pp.

In publishing this volume, the National Committee for the Prevention of Blindness undertakes to serve as a clearing-house for the great fund of information regarding this particular hazard of industrial occupations developed by the numerous industrial associations, governmental agencies and individual corporations interested in accident prevention and health promotion. An idea of the scope of the work can be gained from the titles of the 10 chapters composing the book: introduction to the problem, nature and cause of eye injuries, eliminating eye injuries by engineering revision, industrial eye accidents and means for their prevention, first-aid treatment for eye injuries, the correction of defective vision, diseases affecting the eyes, industrial lighting, education as to safety, the safety movement and its effect on the eye hazards in industrial occupations.

Complete Report of the Olympia Automobile Exhibition. Published in *The Motor*, Oct. 21, 1924, p. 589. Illustrated.

The cars exhibited at Olympia are listed in alphabetical order; each name is accompanied by a description of noteworthy features of the car and in most cases by an illustration of the car or some part thereof. Similar treatment is accorded the coachwork and the accessories in the Olympia Exhibition.

A New Oil-Engine Indicator. Published in *The Motor Ship*, October, 1924, p. 256.

An instrument is described that has been developed by a British builder of Diesel engines for the purpose of obtaining accurate records of the pressures throughout the cycle of operations.

American and British Oil-Engine Practice Compared. By Verena Holmes. Published in *Motorship*, September, 1924, p. 663.

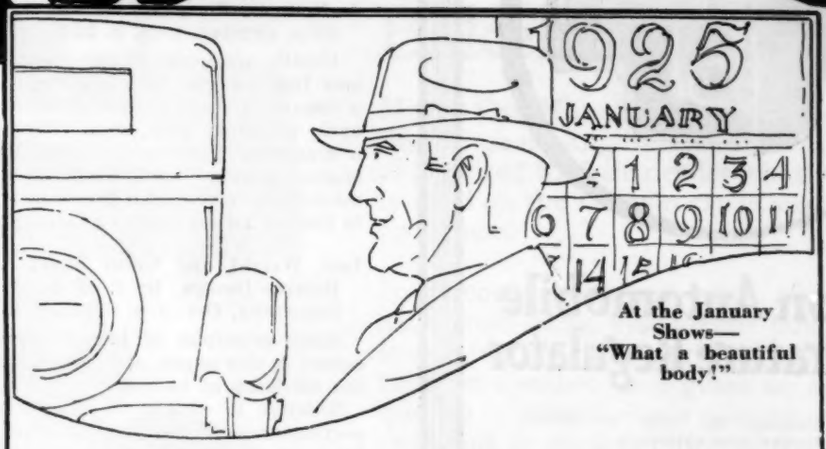
This article contains a discussion of current marine designs from the viewpoint of a British woman engineer.

Development of the Hot-Bulb Engine. By C. S. Darling. Published in *The Motor Ship*, October, 1924, p. 252.

The main features of the design and the upkeep of the hot-bulb engine are compared with the corresponding features of Diesel machinery. The hot-bulb engine is said to differ from the Diesel engine in that it does not use the injection-air spray for atomizing fuel and from the mechanical-injection engine because it does not employ a water-cooled combustion-chamber, although the tendency is for a greater

(*Continued on p.* 20)

Raulang



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BEAUTY of appearance is important at the Shows and on your sales floor. But after the car is *sold*, "beauty is as beauty does." Right there are two reasons why your car should have Raulang-built enclosed bodies.

And a third is that Raulang facilities make quality possible at as low a *price* as can be obtained anywhere. And a fourth is that the stability of this company, and its record of promise keeping, are your best assurance of beauty, quality and price being *actually delivered*.

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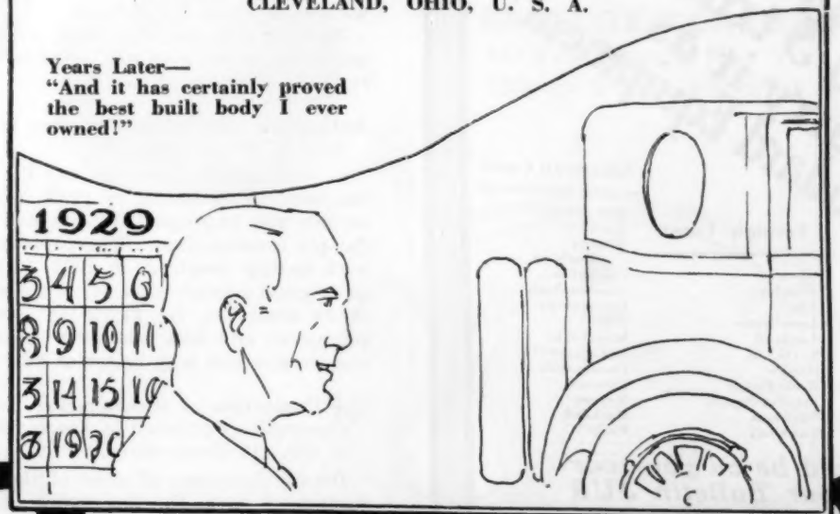
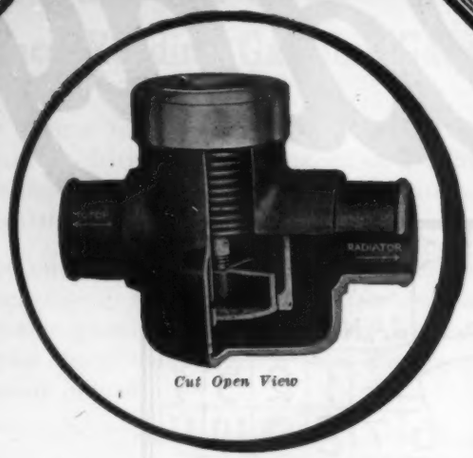


Raulang



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IT *Reduces the wear of valves, pistons and cylinders.*
Reduces crank case dilution and carbon deposits.

IT *Saves 15 to 20 per cent gasoline. Is adapted to pump or thermo-syphon systems. Can be installed between radiator and engine, either in outlet or inlet water connection.*

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NOTES AND REVIEWS

Continued

percentage of the walls of the hot-bulb to be cooled; the hot-spot becomes more localized, while the bulb in this case diminishes in volume until the chamber becomes one with the clearance space, as in the case of cold-starting high-compression engines.

A New Auxiliary Diesel Engine. Published in *The Motor Ship*, October, 1924, p. 244.

Details are given of the design and the construction of a new Diesel engine that in many respects is said to represent a departure from normal practice. It operates on the two-cycle principle with crank-chamber compression, works at a compression-pressure slightly lower than that in a Diesel engine, employs mechanical injection and utilizes an automatic fuel-valve. The fuel consumption is apparently equal to that of an air-injection four-cycle Diesel engine.

Low Weight and Great Shock-Absorption Chief Aims of Bumper Design. By P. M. Heldt. Published in *Automotive Industries*, Oct. 9, p. 642, and Oct. 16, 1924, p. 690.

Basic principles of bumper design and material are discussed in this paper, and suggestions are given for increasing the efficiency of bumpers.

Relative to weight, it is pointed out that, for the same performance or the same degree of protection given, that bumper is the most meritorious which weighs the least. On the other hand, in the case of two bumpers of the same weight, it is obvious that the one which is capable of absorbing the more energy is the more desirable and may therefore be set down as the more efficient. To reduce the weight of the bumper and increase its energy absorbing capacity, the designer must endeavor to dispose his metal so that all of it is stressed substantially equally when an impact occurs, as is done in the design of elliptic springs. Moreover, the weight of brackets and other parts that do not absorb much energy during an impact must be reduced to the minimum.

It is further pointed out that the wider the bumper, the more effective the protection it affords, and for this reason double-bar bumpers have come into extensive use, together with some triple-bar designs.

Bumper tests are described, and a summary of the rules under which bumpers are tested in the Underwriters Laboratories is given.

Automobile Fan-Belts. Published in *The India Rubber World*, Nov. 1, 1924, p. 83.

A brief article discusses (*a*) the amount and the value of fan-belt requirements in 1923, (*b*) service conditions, (*c*) rubber and impregnated belts and (*d*) molded-V, cord and flat-ply constructions. The popular automobiles are credited with having required, in 1923, 22,500,000 ft. of fan belting as original equipment, costing the car-owners, at an average of 20 cents per ft., $4,500,000; this figure is for original equipment and does not cover the 1923 expense for fan-belt renewals, which may be set at half as much more.

The Production of Rickenbacker Engine Parts. By Howard Campbell. Published in *American Machinist*, Oct. 16, 1924, p. 609. 11 illustrations.

Details are given of some of the methods used in the production of parts for the engine of this well-known vehicle. Topics treated include (*a*) boring, reaming and grinding cylinders; (*b*) babbitting connecting-rods; (*c*) grinding pistons; (*d*) lapping piston pins and rings and (*e*) utilizing the power generated on the test block.

Shock-Absorbing Devices. Published in *The Autocar*, Oct. 3, 1924, p. 587. Illustrated.

An introductory statement points out that, on account of the torsional stresses set up by the application of front-

(*Continued on p. 22*)

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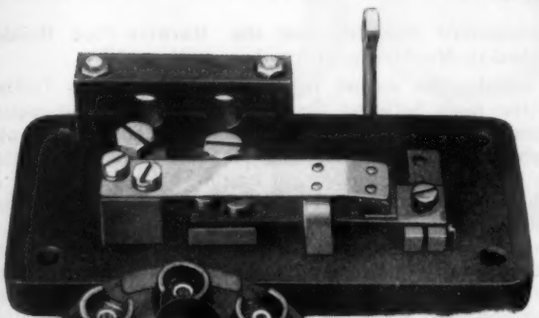

Bakelite molded base of Electro-Fog generator

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Bakelite molded ignition rotor

Bakelite shift lever knob

Bakelite radiator cap

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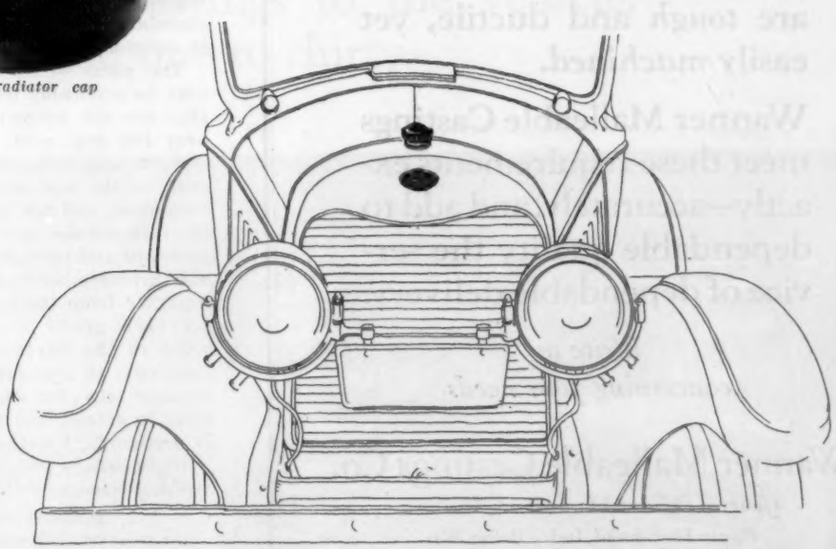

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NOTES AND REVIEWS

Continued

wheel brakes, additional work is thrown upon the front springs and that in helping them to resist these braking stresses shock-absorbers have proved extremely useful. The various types of shock-absorber are reviewed and illustrated.

The Automotive Industry and the Machine-Tool Builder. Published in *Machinery*, November, 1924, p. 179.

This article, the second in a series designed to further cooperative work between the machine-tool and automotive industries, deals with the maintenance problem in the automobile shop, methods of selecting machine-tools, cooperation between salesmen and equipment engineers, qualifications of salesmen and purchasing agents and the problem of production estimates.

Among the details mentioned in machine-tool construction that add especially to the maintenance expense are (*a*) bearings, both sliding and rotating; (*b*) gears; (*c*) cams and (*d*) cone clutches. Each of these topics receives attention in the present article. The need for careful study of production problems is emphasized. In conclusion the opinion of a prominent automotive engineer relative to the inspection system, which he considers the weakest spot in automotive manufacturing practice, is quoted as follows:

> Most inspection systems in automotive plants seem to have for their only purpose to find out that the piece is wrong after a great quantity of wrong pieces have been made. A really efficient inspection system should not merely find out that a thing is wrong after it is made, but should, so far as possible, prevent errors from being made. To accomplish this, the inspection should be in charge of the man at the head of the department, and he should be held responsible for the quality of work passing from his department and for all work spoiled in it. Such a system has been installed in some plants, thereby displacing a great many inspectors who merely passed upon the work after it had been completed.

Light Alloys. By J. B. Swan. Published in *The Automobile Engineer*, October, 1924, p. 293. 9 illustrations; 2 tables.

A general survey of modern practice with regard to the light alloys is given in this article, from the point of view of automobile engineering. The author classifies the various parts of an automobile according to the type of stress and temperature conditions to which they are subjected and then correlates the light alloys, including the latest developments, in accordance with these conditions.

The parts of an automobile in which light-alloy castings may be profitably used are classified as follows: (*a*) the parts that are not subject to severe shock loading or temperature over 100 deg. cent. (212 deg. fahr.), such as the crankcase and the gearbox; (*b*) the parts subjected to dynamic stress, such as the rear-axle casing, the torque tube where such is employed, and the gearbox when carried on the rear axle or the torque-tube end and (*c*) the parts subjected to high temperature and medium dynamic stress, such as pistons, detachable cylinder-heads and the exhaust and inlet-manifolds when separate from the cylinders. The essentials of alloys suitable for each group are described briefly. Some discussion is given of the parts of an automobile suitable for light-alloy forgings; in this connection it is stated that forgings should be used only for such parts as are subjected to large variations in stress, and for which thoroughly homogeneous metal is necessary, together with considerable dynamic strength.

Light alloys suitable for use in automobile manufacture are discussed as follows:

> For general-purpose castings, no special physical properties are necessary. A tensile strength of 9 tons per sq. in. or more is desirable, and a high elongation is an advantage. In the majority of alloys of this type,

(*Concluded on p.* 24)

In 58 of the 58 motor coaches exhibited at the Atlantic City Electric Railway Show-

TIMKEN
Tapered
ROLLER BEARINGS

The exhibitors used an average of 18 Timken Bearings to the vehicle, ranging from one to thirty.

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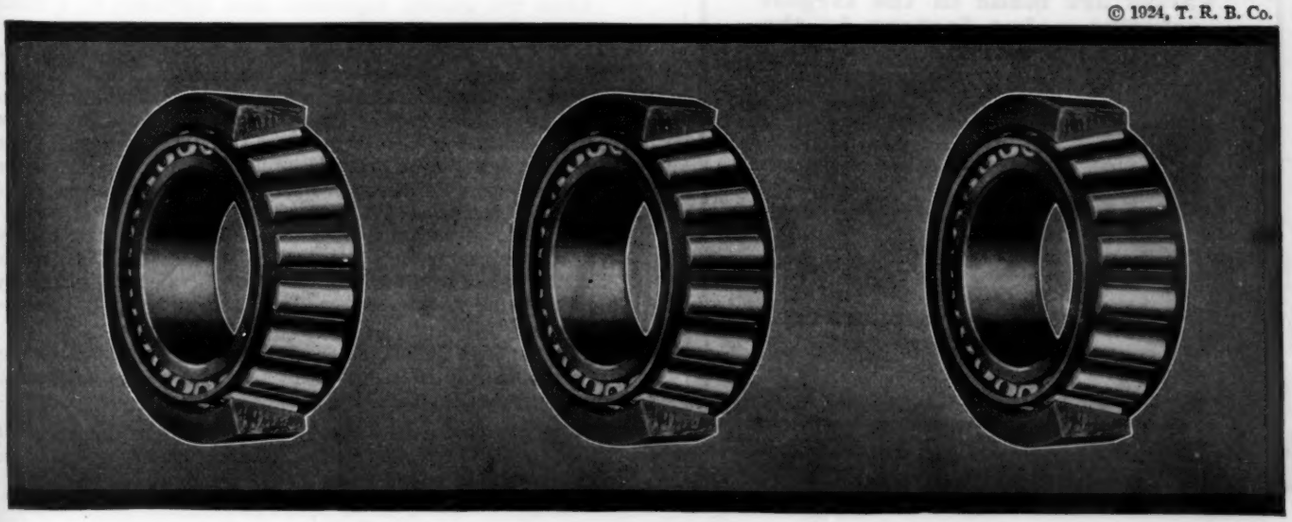

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NOTES AND REVIEWS

Concluded

the elongation, however, is very bad, and a value of 2 per cent extension in a 2-in. gage length or even less is the average. The most important points are a low cost and ease of handling in the foundry. In these respects, the zinc alloys are probably the best. They have an additional advantage of a high tensile-strength and are probably the most used of all the light alloys at the present time.

A large part of the article is devoted to a description of the principal general-purpose alloys, the majority of the physical properties of each being given. The alloys described are the following: the Air Board L.5 alloy, containing 13½ per cent zinc and 3 per cent copper, the remainder being aluminum of commercial purity; the Air Board L.10 alloy, containing 10 per cent copper, 1¼ per cent tin and the remainder aluminum; the Air Board L.11 alloy, containing 10 per cent copper, 1 per cent tin and the rest aluminum; the United States Navy N. alloy, containing 6 per cent copper, about 3 per cent manganese and the remainder aluminum; magnesium alloys; casting alloys suitable for shock loading; the Air Board L.8 alloys, containing on the average 12 per cent copper and the remainder aluminum; the L.7 or the 14/1 alloy, containing a high percentage of copper with a small amount of manganese; the National Physical Laboratory Y-alloy, containing 4.0 per cent copper, 2.0 per cent nickel, 1.5 per cent magnesium, 0.7 per cent silicon, iron as low as possible, and the remainder aluminum; magnesium alloys suitable for exposure to high temperatures, containing 88 per cent magnesium and 12 per cent aluminum; alloys suitable for forging purposes; duralumin, a good average analysis of which is given as 4.0 per cent copper, 1.0 per cent manganese, 0.5 per cent magnesium and the rest aluminum containing from 0.4 to 0.9 per cent silicon; the National Physical Laboratory E-alloy or high-tensile alloy, with an average composition of 18.5 per cent zinc, 2.5 per cent copper, 0.5 per cent magnesium and the remainder aluminum of average silicon content; magnalite, with an average analysis of 1.5 per cent nickel, 2.0 per cent copper, 1.0 per cent magnesium, 0.6 per cent silicon and the remainder aluminum; the National Physical Laboratory 3/20 alloy, which is a forging alloy containing 3 per cent copper, 20 per cent zinc and the remainder aluminum.

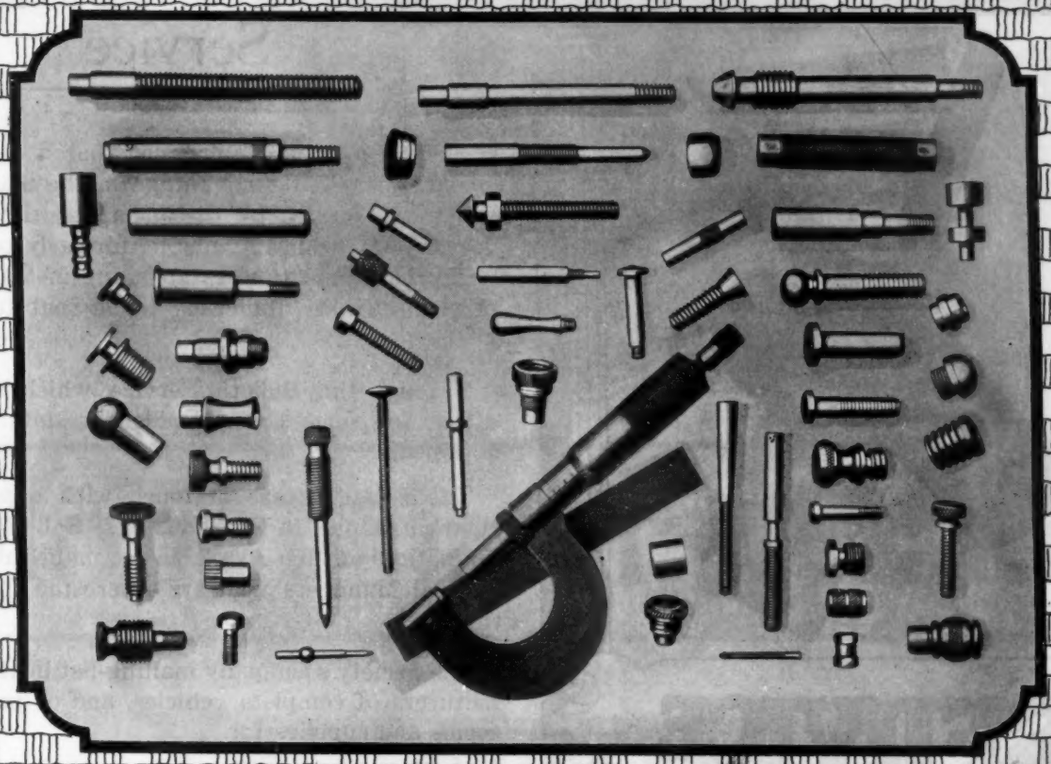
The suitability of aluminum alloys as bearing metals is discussed, and it is stated that in general for high rubbing speeds and loads that are at all comparable to the normal conditions of a white-metal bearing, most aluminum alloys are very unsuitable. An exception in this connection is when aluminum alloys have been used as piston-pin bearings in conjunction with hardened steel pins. Duralumin bushings have also been used as floating bushings in connecting-rod small-ends.

After the general statement that hardness is a factor exerting considerable influence on the general wearing qualities of a metal, it is pointed out that the low hardness of the light alloys as castings is the most serious drawback that they have; it results in the cost of machining being increased in cases where high finish or accurate dimensions are necessary and also they need to be handled with more care than heavy metal castings. The hope is expressed that new alloys may be discovered which will be considerably improved in this respect.

One table gives a list of the various light alloys and the type of component for which each is suitable. The other table contains a list of the conductivities of various light alloys together with steel, cast iron, and the like for comparison.

Duralumin, How It Is Treated, Handled and Protected Against Corrosion. By Horace C. Knerr. Published in *Automotive Industries*, Oct. 9, 1924, p. 648.

Condensed information is given on the characteristics of duralumin and the best methods of treatment and fabrication.



Can you afford cheap screws?

How much do you pay for the screw machine products that you scrap because of imperfect fit, stripped threads or poor finish? How much time is wasted in making imperfect parts fit?
Check these figures up in your own plant. You'll be surprised at the amount which could be saved merely by specifying NAMCO-made Screw Products.
That's rather a strong statement, but specify NAMCO on your next order and check up for yourself.
You'll find NAMCO parts to fit snugly where they belong—uniformly accurate—with clean cut threads—parts of exceptional finish.

Let NAMCO Save for You.

From stock—

U.S.S. Cap Screws, Milled or Upset.
S.A.E. Cap Screws, Milled or Upset.
U.S.S. Set Screws, Milled or Upset.
S.A.E. Milled Nuts, Plain or Castellated.
Hexagon Brass Nuts.

The National Acme Company Cleveland

New York Chicago Detroit

Makers of Acme Automatics, NAMCO Threading Dies and Collapsing Taps at Cleveland, Ohio, and Gridley Multiple and Single Spindle Automatics and Gridley Chucking Machines at Windsor, Vermont.

SERVICE
FLOOD OILING
FAN
A Flood-Oiling Fan is another step toward perfection in your product. Running in a bath of oil—self-contained—just as in your transmission and differential. Neglect-proof. Insurance against wear and rattle. "Flood-Oiling fans last as long as the motor."
Would you like to test it on your experimental car?
SERVICE PRODUCTS CORP.
201 S. Rural St., Indianapolis, Ind.
How about working in
BRANCH OFFICES
526 Madison Terminal Bldg. Chicago
205 Kresge Bldg. Detroit
"If it's a flood-oiling fan —it's a service fan"

S. A. E. Employment Service

The Society has determined that it can assist its members to better advantage in the matter of employment service by discontinuing the notices of Men and Positions Available, formerly published in THE JOURNAL, and establishing instead a system of Semi-Weekly Bulletins, to be sent to members upon request.

Through this Bulletin Service, which has been in effect for some time, excellent results have been obtained.

The Society keeps in touch with approximately 1000 companies in the industry. Bulletins containing notices of Men Available are mailed regularly to General Managers who are interested in receiving them.

The Society's company mailing-list includes manufacturers of complete vehicles, and of parts, accessories and supplies for

Motor Cars
Trucks
Tractors and Farm Machinery
Motorcycles
Stationary Internal-Combustion Engines
Motorboats
Aircraft
Motor Railway Equipment

Contact is also maintained with technical schools and publishers of trade magazines.

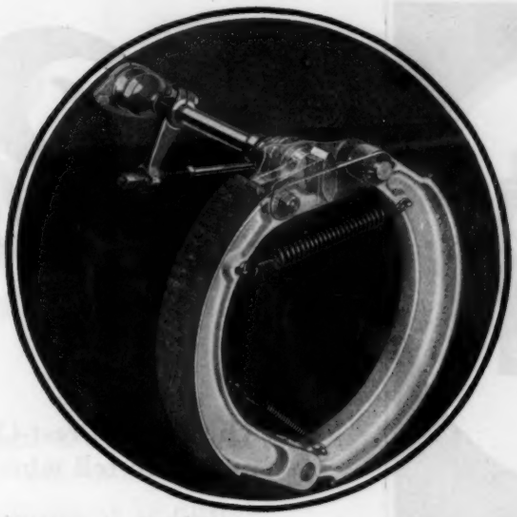
Men registered as Available for employment include

General Managers and Technical Assistants
Consulting Engineers
Chief Engineers and Assistants
Designers and Draftsmen
Research Men and Experimental Engineers
Metallurgists
Production Executives and Assistants
Service Managers and Assistants
Sales Managers and Sales Engineers
Technical Writers and Editors
Instructors and Graduate Engineering Students

When requesting that bulletins be sent to you, please specify whether you wish the bulletin of Men Available or that of Positions Available.

Address: S. A. E. Employment Service
Society of Automotive Engineers, Inc.
29 West 39th Street New York City

Sections Secretaries receive the Bulletins regularly.



More efficient brakes

YOU like any mechanism that shows greater efficiency—more actual "work" capacity, for a given amount of applied power.

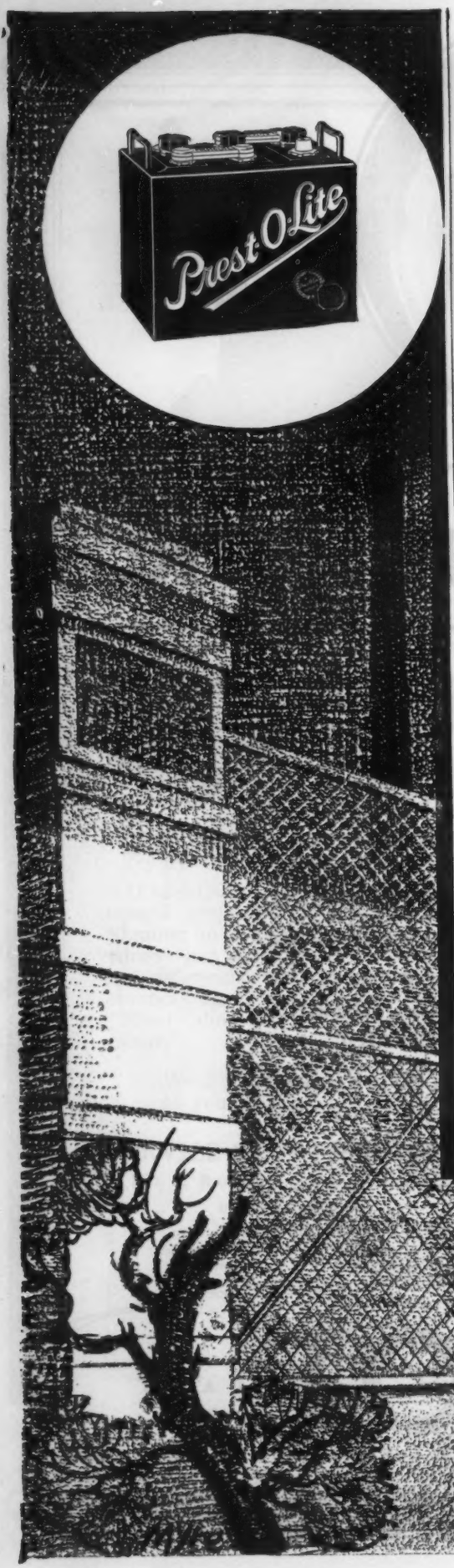
Through the action of Perrot Self-Energizing Brakes, a gentle pressure on the foot lever is multiplied into a powerful positive braking action, yet free from chatter, grab, or squeal.

In no other form of brake is secured that unbroken smoothness of stopping power, the quickness of deceleration, and the instantaneous release at the will of the operator.

You've been wanting these more efficient brakes. We build them for you; so successfully standardized that you'll find them economically applicable to any layout.

PERROT BRAKE CORPORATION
SOUTH BEND, INDIANA, U.S.A.
Subsidiary of Bendix Engineering Works

PERROT
MECHANICAL-STANDARDIZED
4-wheel BRAKES



Prest-O-Lite

THE OLDEST SERVICE

The name Prest-O-Lite on a battery isn't there merely to tell who made it—

Rather it assures reliable performance, built into the battery itself; it reflects the most minute care in selection of materials, expert skill in construction and assembly, and thorough inspection; it signifies prestige built upon ideals which prohibit the production of anything save the best.

The name Prest-O-Lite is assurance of battery satisfaction—that is why Prest-O-Lite batteries are standard equipment on a large and ever-growing list of America's famous automobiles.

A Prest-O-Lite PRODUCT
WORLD'S LARGEST MANUFACTURER OF ACETYLENE THE GAS OF A THOUSAND USES
BATTERIES FOR AUTOMOBILES, FARM LIGHTING, RAILWAY SIGNALS AND RADIO

The Sign of "Friendly Service"

Service Stations Everywhere

O-Lite

TO MOTORISTS

Prest-O-Lite Gas is the standard for truck lighting. It sets the standard for efficient lighting, economy in operation and simplicity in installation.

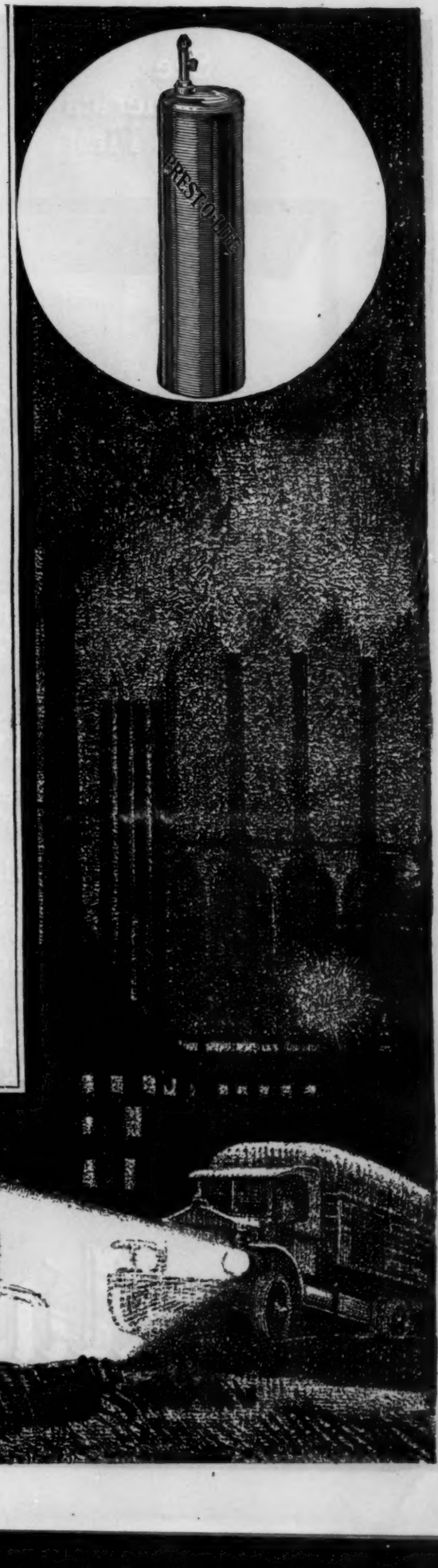
There are no moving parts to break or wear out. It gives a constant, clear light in all kinds of weather, and under all road conditions. It is approved by public authorities.

Prest-O-Lite outlives the truck.

Thirty-six big gas producing plants supply thousands of Prest-O-Lite Exchange Stations scattered all over the country. You can always get a full tank for your empty one by paying a very small amount for the gas only.

The Sign of Universal Gas Service — Prest-O-Lite Gas Service — *The Gas of a Thousand Uses*

THE PREST-O-LITE COMPANY, Inc.
INDIANAPOLIS, IND.
New York: 30 East 42nd Street
Pacific Coast: 599 Eighth Street, San Francisco
In Canada: Prest-O-Lite Company of Canada, Ltd., Toronto



See America First

Ainsworth PRODUCTS

Through Ainsworth Windshields

The Confederate Memorial
Now Being Executed by Gutzon Borglum
Stone Mountain, Georgia

TRIBUTES

Great achievements, causes and epochs have ever inspired tribute from mankind.

The present-day motor car is one of the world's greatest mechanical and industrial achievements, made possible by the finest engineering and manufacturing practices.

The fact that Ainsworth Products reflect the highest class workmanship and the most exacting standards of material and construction is our constant tribute to the industry of which we are a part.

AINSWORTH MANUFACTURING COMPANY
Detroit, Michigan

Ainsworth
PRODUCTS

Riding Them *Soft*

MOST cars are driven with tires *under-inflated.* Part of the time at least. Under-inflation means easier riding—and much harder steering. Here again, the Ross Cam and Lever Steering Gear solves a problem that every manufacturer faces.

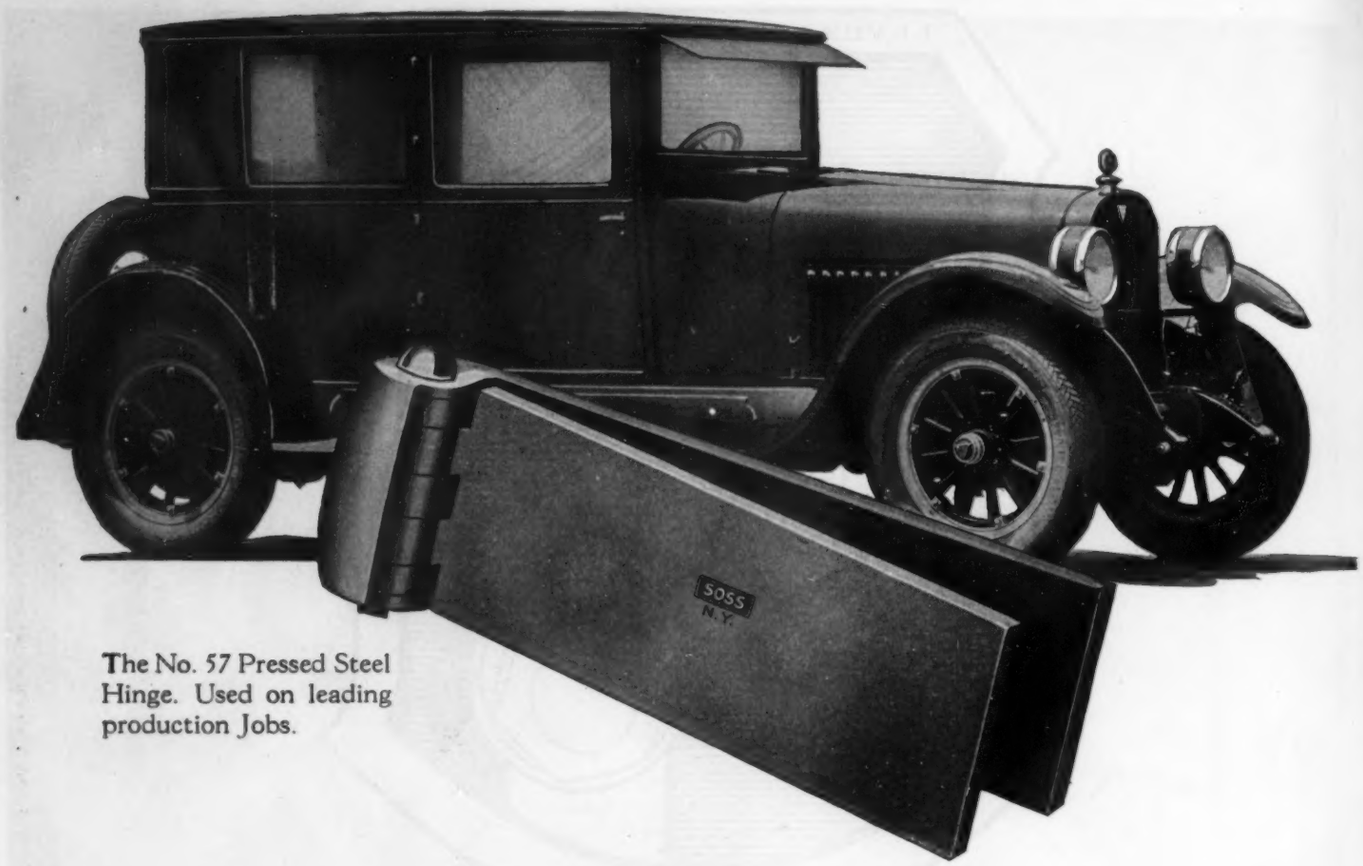
Write for the facts

ROSS GEAR AND TOOL COMPANY, *730 Heath Street,* Lafayette, Indiana

ROSS

CAM *and* LEVER STEERING GEARS

EASIER STEERING LESS ROAD SHOCK



The No. 57 Pressed Steel Hinge. Used on leading production Jobs.

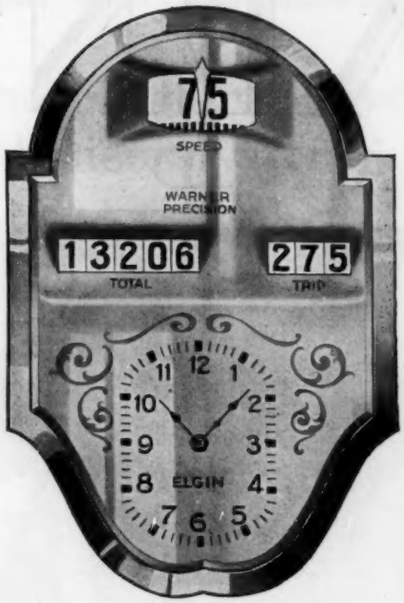
Over three-quarters of a million SOSS Pressed Steel Hinges have been used on HUDSON & ESSEX Coaches.

SOSS MANUFACTURING COMPANY, Inc.
GRAND AVE. & BERGEN STREET, BROOKLYN, N. Y.
535 Book Bldg., Detroit, Michigan.

Door Hinges
Door Handles

SOSS

Door Bumpers
Die Castings



Designed to grace the instrument boards of the finest cars in the world

STEWART-WARNER SPEEDOMETER CORPORATION
CHICAGO, U. S. A.

79

The model illustrated on this page is a special design of the famous "79" WARNER PRECISION SPEEDOMETER *the last word in speed recording instruments*

ATWATER KENT

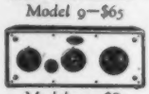
RADIO

Radio Enjoyment for Every Occasion

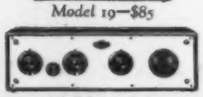
Model 12—$105

Model 10—$85

Model 9—$65



Model 19—$85



Model 20—$100

De Luxe Model—$120

Pacific Coast prices slightly higher

FOR the owner of Radio there is more and better broadcasting than ever before. Concerts, operas, lectures, sermons, educational courses, market, weather and special reports, and always the thrill of unexpected announcements of important happenings.

ATWATER KENT Radio in your home will assure you countless evenings filled with joy.

You will find ATWATER KENT Receiving Sets and Loud Speakers well within your means. To fully appreciate their many advantages, see the new Models at any radio dealer's.

Note the materials used in their construction; the best that money can buy. Feel how smoothly the dials turn; that's but one example of their master workmanship. And then listen to the remarkable reception. Note the ease with which you can bring in stations with ample volume, even from a distance.

For selectivity, distance, volume, clear reception, simplicity of operation and beauty of design, ATWATER KENT Radio is unexcelled.

These qualities your radio must have to give you perfect satisfaction. Be sure of getting them all by buying ATWATER KENT.

Instructive literature on request

ATWATER KENT MANUFACTURING COMPANY
4736 Wissahickon Ave., PHILADELPHIA, PA.

Model R $15 Model M $28 Model L $20

Bring out the best from any set

AN ATWATER KENT Loud Speaker will add to the enjoyment of your radio. Its faithful reproduction of sound, clear and full in volume, enhances the value of any set and completes radio satisfaction.

Its quality is as fine as the best materials and master workmen can make it. Its design, correct in every detail, is a triumph in loud speaker production.

You need an ATWATER KENT Loud Speaker to bring out the best from your set.

THINK OF WHAT IS BACK OF IT

BOWEN SYSTEM

A Single pressure of the foot lubricates every chassis bearing automatically and simultaneously. It makes the chassis as easily lubricated as the motor. As simple to operate as the starter.

WHAT THIS MEANS TO THE MANUFACTURER

For the first time in the industry, the car manufacturer is secure in his knowledge that his car is being properly lubricated. No longer is the value built into his product at the mercy of hit and miss or makeshift methods. Owner dissatisfaction, arising from premature wear with resultant repair bills, directly traceable to ineffective lubrication, is eliminated. That is accomplished with the BOWEN SYSTEM of chassis lubrication as standard equipment.

WHAT THIS MEANS TO THE DEALER

Less sales resistance. He knows the car owner is disgusted with present, obsolete methods of chassis lubrication and naturally ignores this point so far as possible in his sales arguments: then, too, practically every sales point he can bring up is common to any number of other cars —a new model; a change in body lines; a little gadget, more or less, here and there means little to the average car owner. What he wants is dependability in every part plus comfort together with as little maintenance expense in time and money as possible. With the fact accepted, that 80% of his expense for repairs is due to inadequate or ineffective lubrication, he will favor the car equipped with a system of lubrication easy to operate and upon which he can depend. The BOWEN SYSTEM, on the car the dealer handles, provides a powerful selling point.

WHAT THIS MEANS TO THE CAR OWNER

No more disagreeable, time consuming, messy jobs going over each bearing with a grease gun or similar device. No grease cups to fill and fuss with. Elimination of annoying squeaks and rattles. No more excessive depreciation with attendant bills for repairs and new parts occasioned by ineffective lubrication. With the BOWEN SYSTEM as a part of his car, he enjoys a sense of security and freedom from drudgery in relation to his car hitherto impossible.

BOWEN PRODUCTS CORPORATION
AUBURN DIVISION AUBURN, NEW YORK

It is now standard equipment on the Cleveland, all models, and is under consideration by other leading car and truck manufacturers.

FOR ALL MOTOR CARS & TRUCKS

Formica Grade R magnified 2 times

Another Non-metallic Gear Material magnified 2 times

Formica is a strong Non-Metallic Gear Material

CAREFUL development work in the Formica laboratories has produced a material for non-metallic gears that has very exceptional strength in both directions.

Examination of a section of this material will disclose almost twice as many laminations to the inch as is used in many materials of the kind. The duck base has been specially woven, and the Formica sheet made to assure equal strength in both directions.

The Formica binder has been standardized at a degree of hardness that is most suitable to the greatest number of uses.

Each Formica blank is submitted to a process, somewhat similar to that of annealing steel which eliminates the possibility of erratic expansion even when the blank is run in hot oil.

Formica blanks are as uniform as a good grade of steel made always in the same mill. Formica users find that Formica consistently outwears the non-metallic gear materials they formerly used.

Write for literature and prices.

THE FORMICA INSULATION COMPANY
4648 Spring Grove Avenue, Cincinnati, Ohio

FORMICA
Made from Anhydrous Bakelite Resins
SHEETS TUBES RODS

BUNTING
BUSHING BEARINGS
PATENTED

Rice Leaders of the Worth Association

Send Your Bushing Specification Data to BUNTING

THE ability of this company to serve the user of bronze bushing bearings includes every conceivable requirement. If you want a few bushing bearings you can buy them from Bunting for less than you can make them yourself—usually for less than the rough castings cost anywhere else. If your requirements run into volume, or involve complicated problems of alloy and design, you need the capacity, skill and responsibility of this old, established company. Counsel and quotations promptly rendered on request.

Hang Bunting's Stock List L in your drafting department. This card shows 300 sizes of completely machined and finished Bunting Phosphor Bronze Bushing Bearings always carried in stock. Quick delivery. A low price on small lots. Get these standardized sizes into your blue prints.

THE BUNTING BRASS & BRONZE COMPANY · TOLEDO, OHIO

Branches and Warehouses at

NEW YORK
245 W. 54th St.
Columbus 7528

CLEVELAND
710 St. Clair Ave., N. E.
Main 5991

CHICAGO
722 S. Michigan Ave.
Wabash 9153

PHILADELPHIA
1330 Arch St.
Spruce 5396

SAN FRANCISCO
198 Second St.
Douglas 6245

BOSTON
36 Oliver St.
Main 8488

Bearings, Bushings, Bearing Metals.

Specializing on these few products and having no side lines, we still find that it takes all of our time and thought and all the time and thought of the best experts that we can employ to produce nothing but Bearings, Bushings and Bearing Metals worthy of the mark

Mogul FEDERAL

Doing but one thing and doing it with all our energy, possibly explains why over 50 automotive manufacturers use and prefer Federal-Mogul products.

FEDERAL-MOGUL CORPORATION
DETROIT, MICHIGAN.
WORLD'S LARGEST ENGINE BEARING MANUFACTURERS
A consolidation of the Muzzy-Lyon Company and the Federal Bearing & Bushing Corporation.

Dole

Double Compression COUPLINGS

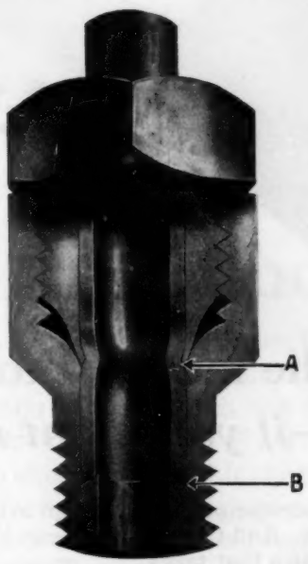
for Oil and Gasoline Lines

"The Perfect Nonleakable-Re-connectable Joint"

Note the Double Joint

A—where the screw compresses the tube.

B—where the tube is swedged into the "V" slot.



Absolutely insures against vibration and leakage. This fitting requires no soldering, no brazing, no flaring of the tubes and no sleeves.

Following are some of the users of Dole Products

MOTOR CARS

Buick
Barley
Bay State
Checker Cab
Cleveland
Dort
Elcar
Franklin
H. C. S.
Kurts
Kissel
Fageol
McFarlan
Maxwell
Nash
Oakland
Overland
Pilot
R & V
Rollin
Rickenbacker
Stutz
Stephens
Studebaker
Sayers
Willys-Knight
Yellow Coach

TRUCK and TRACTOR

Ahrens Fox Fire Engine
Available Truck
Advance-Rumley
American-LaFrance Fire Engine
Armleder Motor Truck
American Steam Truck
C. L. Best Tractor
Buffalo Truck & Tractor
Chicago Motor Truck
Garford Motor Truck
Hal-Fur Motor Truck
Indiana Truck
International
Nelson Bros. Truck
Rock Island Plow
Stoughton Truck
Seagrave Fire Engine
Wisconsin Farm Tractor
Wilcox Truck

ENGINE MFRS.

Associated Mfrs.
*Buffalo Gasoline Motor
Century Motors
*Baker Motors, Inc.
Cushman Motor
Falls Motor
Hercules Gas Engine

ENGINE MFRS. (continued)

Ideal Engine
International Motor
**Laurels Motor
Le Roi
New-Way Motor
Nichols & Shepard
Novo Eng. Co.
Schram, Inc.
Universal Motor
Universal Products Co.
Waterloo Gas Engine
Waukesha Motor
Weber Engine
Wilson Fdry. & Machine Co.
**Kohler
**Lycoming

ACCESSORY MFRS.

Wm. Akers, Jr., Co.
Bassick Mfg. Co.
Champion Pneumatic Mach'y Co.
Folberth Auto Spec. Co.
Lucas Pump & Tool
Kellogg Mfg. Co.
Stewart-Warner Speedometer Corp.
Trico Products Corp.
Universal Device Co.

The Dole Valve Co., 1923 Carroll Ave., Chicago, Ill.

Make It Easy

for the motorist to care for your car
—if you want repeat customers

OIL, water, air—Sure! It's *chassis lubrication* that the motorist neglects 9 times in 10. And there's where he gets the irritating toll of repairs that takes the joy out of his motoring.

So make chassis lubrication simple, convenient and sure. The Alemite High Pressure Lubricating System does it as no other can. This is why.

One standard fitting for every chassis bearing,—as well known as a tire valve. A simple, sure method of applying lubricant,—that assures reaching and covering the actual bearing surfaces. 20,000 or more service stations the country over,—making Alemite lubricating service as convenient as oil or gasoline service for the motorist. A continual educational advertising campaign in the leading magazines, reminding motorists of chassis lubrication.

That's why the Alemite fitting gets better lubricating attention from the average motorist than any other system. Ask any service station. Alemite fittings invite lubrication.

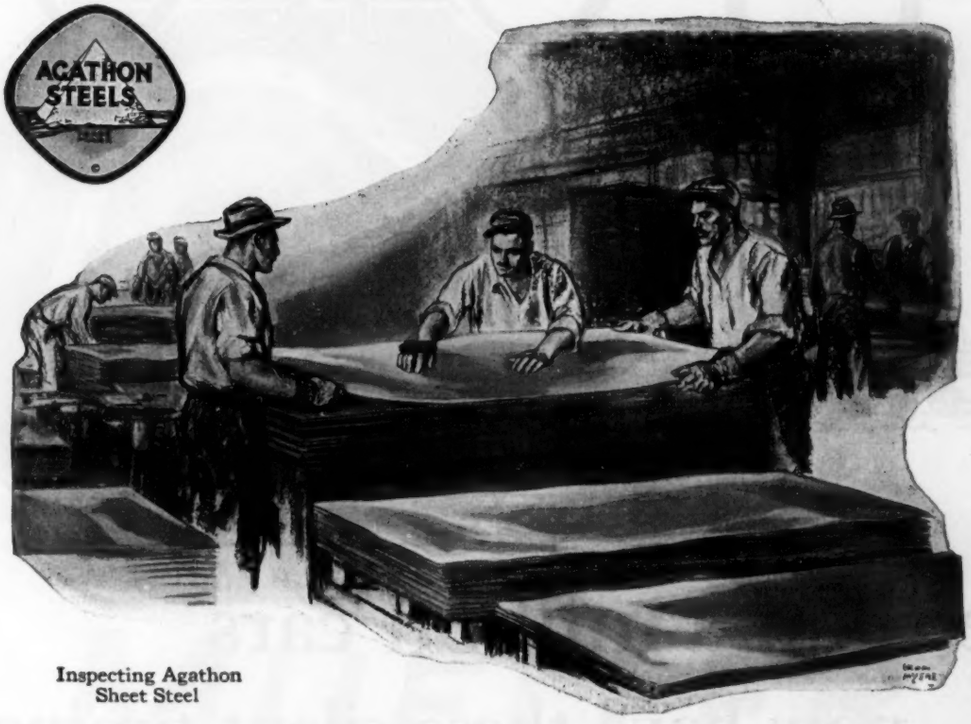
. . . .

That's what keeps the Alemite-equipped car out of repair shops. And that's what makes repeat customers for your car.

THE BASSICK MANUFACTURING COMPANY
2634 North Crawford Avenue Chicago, Illinois
Canadian Factory: Alemite Products Co. of Canada, Ltd.
Belleville, Ontario

A Bassick-Alemite Product

ALEMITE
High pressure lubricating system "Reg. U. S. Pat. Off."



Inspecting Agathon Sheet Steel

Inspection of Agathon Sheets

ONLY years of careful training and a complete knowledge of the ultimate use of Agathon Sheet Steel, make it possible for these men to distinguish the defects that are objectionable to users of this grade of sheets.

Careful inspection of each sheet by these highly trained men, insures shipment of clean, smooth, highly polished material; and modern pyrometer control of all annealing furnaces, eliminates the possibility of any variation in drawing and forming qualities.

Agathon Sheets have an enviable reputation among Motor Car Builders, Body Manufacturers, Stamping Plants, Steel Furniture Manufacturers, etc., who demand the highest grade sheet possible to produce.

Use Agathon Sheet Steel for

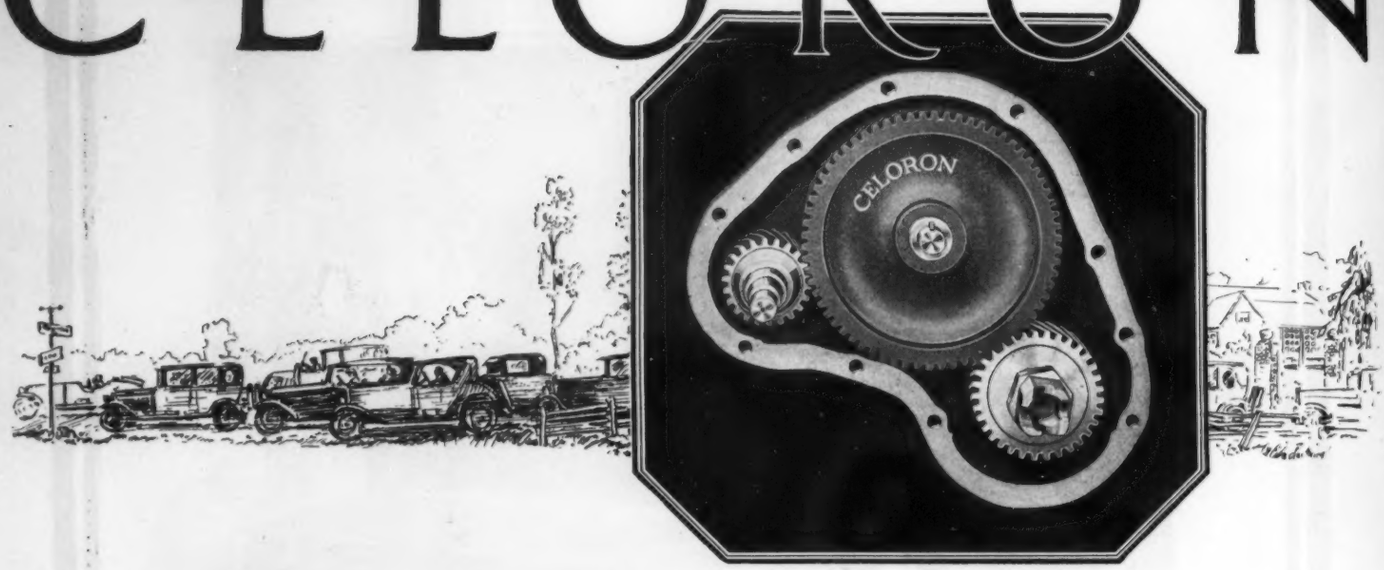
Automobile Bodies
Cowls
Hoods
Crown Fenders
Metal Furniture
Metal Doors and Window Casings
Railroad Car Interiors, Etc.

THE CENTRAL STEEL COMPANY, Massillon, Ohio

Swetland Bldg., Cleveland
Aeolian Bldg., New York
Book Bldg., Detroit
University Block, Syracuse
Peoples Gas Bldg., Chicago
Widener Bldg., Philadelphia

AGATHON SHEET STEEL

CELORON



More than a million cars

now have these silent timing gears

MAKERS of quality cars have found the way to quiet front ends. They have equipped their cars with modern, noiseless timing gears.

Many of these manufacturers, after exhaustive tests, selected Celoron Silent Timing Gears. They made their timing trains positive in action, *permanently silent*.

Celoron is a laminated phenolic condensation material bonded with bakelite. It is tough, resilient, non-absorbent. It does not warp or swell. It reduces wear and tear, lessens vibration, cushions shocks.

Jobbers and dealers everywhere carry stocks of Celoron Silent Timing Gears for the replacement trade.

Be sure you get genuine Celoron Silent Timing Gears. Look for the "Celoron" mark.

In many plants Celoron Silent Gears are used for direct drive on large and small production machines. These gears drive big punch presses, cranes and pumps, effectively and silently.

There are dozens of mechanical and electrical uses for Celoron. It has a wide application to insulating needs. It is easily machined; can be sawed, drilled, punched, turned, threaded, and milled. It does not absorb moisture.

Diamond State Fibre Company

Bridgeport, Pa., and Chicago, Ill.

The oldest and largest manufacturer of vulcanized hard fibre and laminated bakelite materials in the world.

Wherever chimneys smoke and wheels turn there are countless electrical and mechanical uses for Celoron and Diamond Fibre.

Consult Mueller for Brass

Mueller is the largest manufacturer of brass forgings in the world.

Relleum Brass Forgings are adaptable to every line of manufacture where brass parts are used.

MUELLER

Relleum Brass Forgings add strength and lower costs

Mueller Manufactures:

Red Tip Brass Rod
Relleum Brass Forgings
Niag Nickel Silver Rod
Sandcraft Brass Castings
Brass Screw Machine Parts
Blue Tip Tobin Bronze Rod
Brass and Copper Seamless Tubing
Mueller Tobin Bronze Welding Rod

—*because*—intricate designs can be forged, eliminating or reducing machine work—surfaces are smooth—tolerances are close—and they are twice as strong as sand castings.

Your inquiry, with samples or drawing, submitted to our Engineering Staff will allow us to prove that it pays to put your brass problems up to Mueller.

Mueller, Port Huron, Michigan
Associated with Mueller Co., Decatur, Ill., and Sarnia, Ont.

Mueller Forges Brass!!

Keep This On Your Desk
Compare these Advantages with Other Makes
1. Heat Treated (By Ferry Laboratories)
2. Bright Finish (By Ferry Methods)
3. Heads Die Made (By Ferry Patents)
4. Smooth Hex Heads (By Ferry Process)
5. 18 Years Experience (By Ferry Pioneers)
6. Nationally Preferred (Buy Ferry Screws)
"If it's Upset—it must be Heat-Treated"
Compare with Other Makes

Did You Get Yours?

If you did—that's fine. If not, write us at once for your sample of this wonderful Ferry Heat-Treated, Bright-Finished Upset Cap Screw. We are holding it for you. Keep it on your desk—compare its many advantages with other makes.

Then—compare prices. Never again will you have the opportunity of buying cap screws of such superior quality at the ridiculously low prices that now prevail. Business is picking up fast, the demand is increasing rapidly and it is impossible for us to guarantee these prices for any length of time. Better act quick. Write or wire us for your sample and prices.

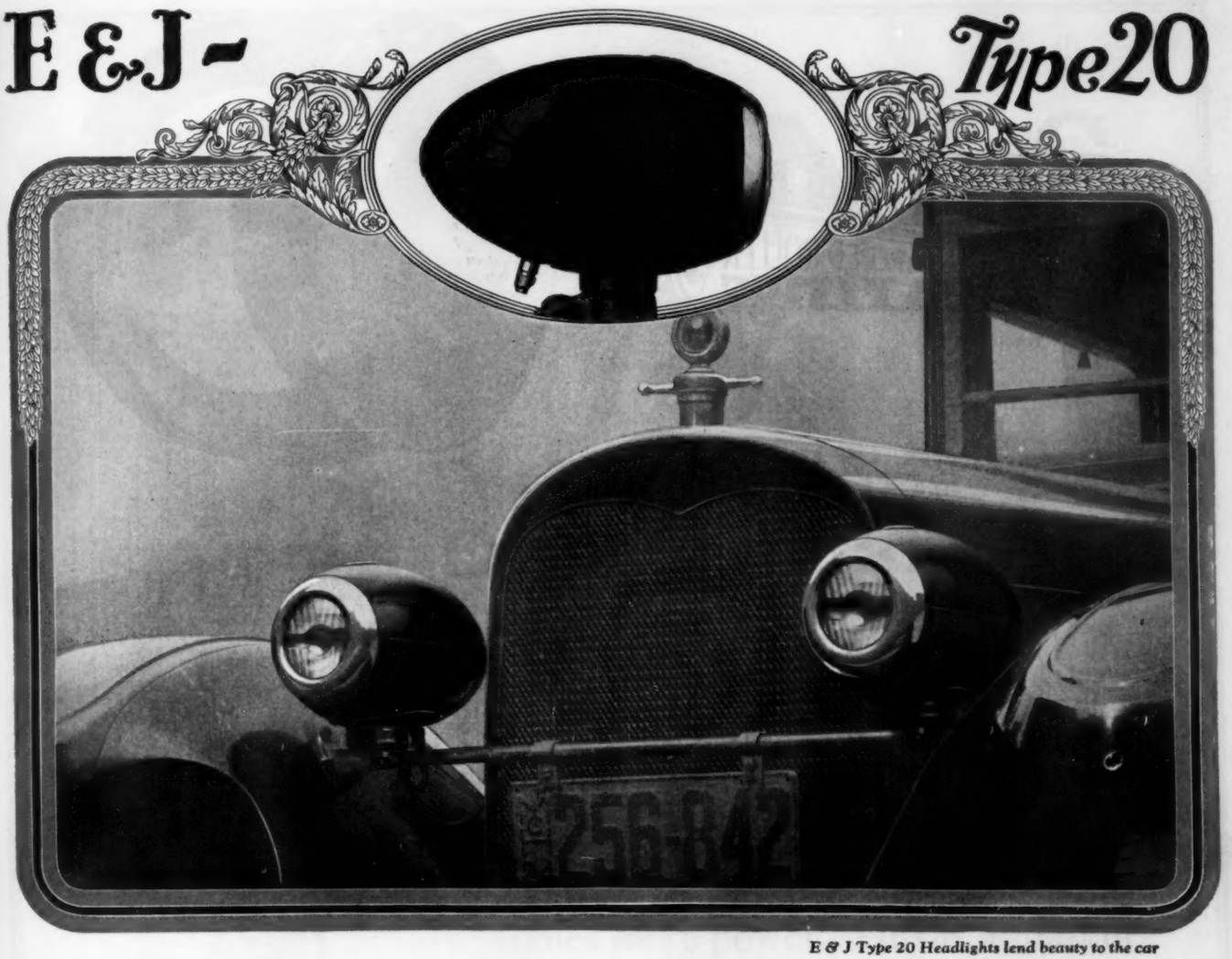
"If it's upset—it must be heat treated"

THE FERRY CAP & SET SCREW COMPANY, Cleveland, Ohio

FERRY

PROCESS SCREWS

E & J - Type 20



E & J Type 20 Headlights lend beauty to the car

The Answer To Safe Night Driving

Unretouched night photograph showing light pattern on road

E & J Type 20 Headlights do much more than enhance the appearance of a motor car. The ideal illumination of these scientific headlights provides absolute protection for the driver and passengers in automobiles traveling through the night.

Of course the menace of glare is missing from E & J Type 20 Headlights because of the amber color filter, which removes the dazzling rays from the upper portion of the beam. Then the aplanatic lens confines the light projected to the width of roadway and ditch. And finally, there is a uniform volume of light hundreds of feet ahead of the car—free from shadows and "spots"—which means freedom from eye strain.

Whether oncoming drivers "dim" or not, the car equipped with E & J Type 20 Headlights is able to proceed with safety because of sufficient light projected *beyond the approaching car.*

These salient safety factors, together with the fact that E & J Type 20 Headlights are legal in every state and do not require dimming, are responsible for this new, complete lighting unit enjoying the reputation of being "the safest light in motordom."

Do Your Part to Enforce Correct Automobile Lighting

EDMUNDS & JONES CORPORATION

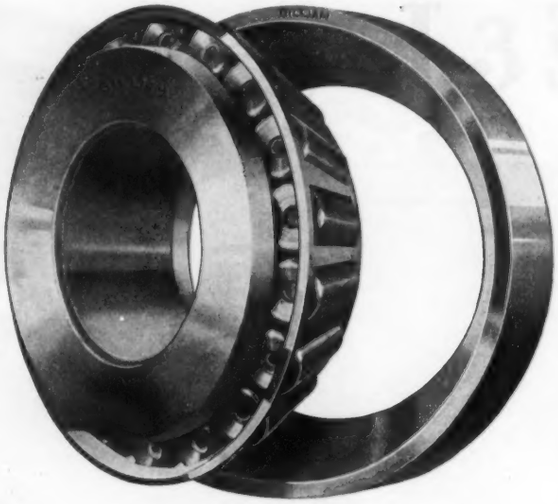
For Twenty Years The World's Largest Manufacturers Of Quality Motor Lamps

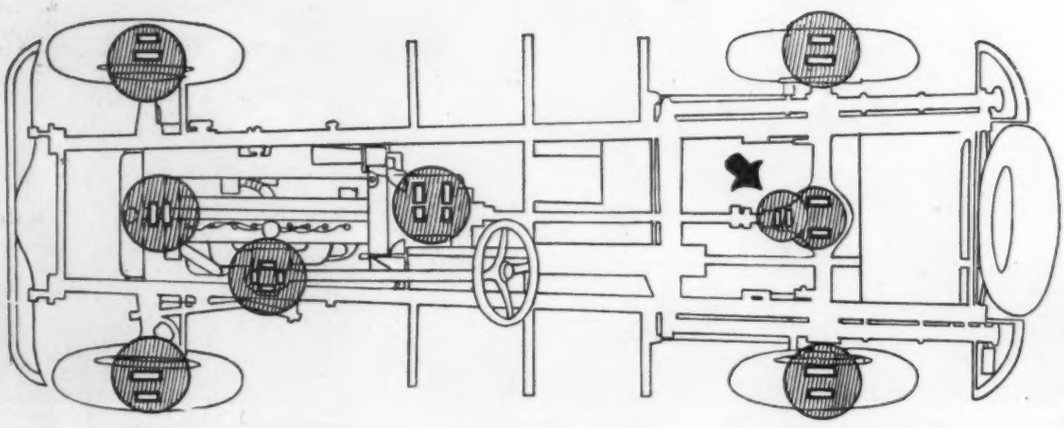
DETROIT, MICHIGAN

"The Safest Light in Motordom"

Manufactured under Bone Patents 8-30-21 and 1-15-24, other Patents Pending

GILLIAM TAPERED ROLLER Bearings





And on the pinion shaft—

The arrow symbol signifies the recognized ability of Gilliam Tapered Roller Bearings to carry all combinations of radial and thrust loads from all directions.

Where the speed and load conditions are most severe Gilliam *Steep Angle Type* Bearings assure thousands of miles of satisfactory carefree service.

Their high grade alloy steel construction and advanced features of design make them ideal for this installation.

Our engineers will gladly explain the details.

THE GILLIAM MANUFACTURING COMPANY

CANTON, OHIO

DIXON'S 677

For Transmissions and Differentials

is unaffected by low temperatures and shows minimum power losses during winter months.

The average gear lubricant congeals at freezing temperature and consumes more power. This is apparent by the difficulty of shifting gears.

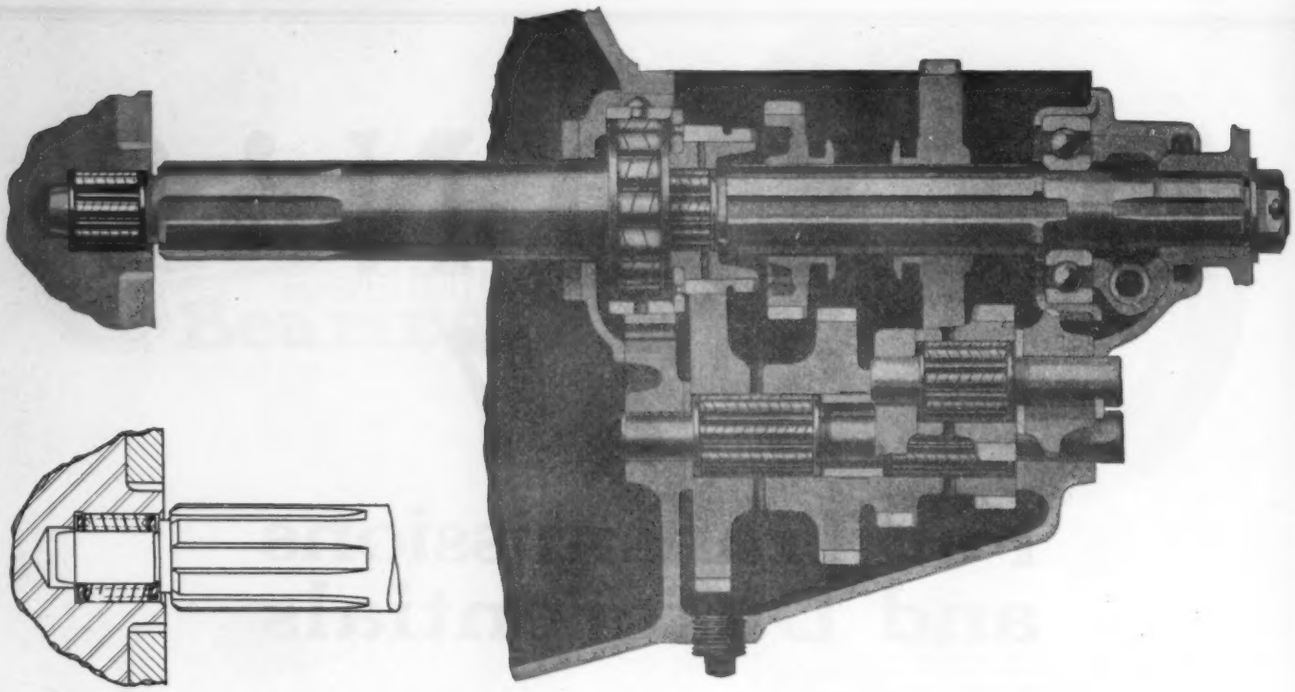
The ability of Dixon's 677 to withstand extremes of cold results in an actual reduction of power-losses and an elimination of added strains to which parts are subjected when the lubricant is too hard.

Dixon's 677 may be obtained in steel drums with pump, providing a quick, clean means of lubricating gear-boxes. A necessity in every garage and service station. Write for quotations.

JOSEPH DIXON CRUCIBLE COMPANY

Jersey City New Jersey

Established 1827



Higher Quality Transmissions at Low Cost

No. 5 *Clutch Pilot*

Competition today demands improved motor car construction at an even lower cost. Automotive engineers are solving this problem at the clutch pilot position through the use of Hyatt roller bearings. Mounted in the end of the crankshaft, as illustrated, a Hyatt roller assembly —

1. Eliminates the most common cause of complaint at this location — faulty lubrication. Once packed with grease it needs no further attention.

2. Affords quiet operation. Hyatt rollers dampen noises, do not freeze, whistle or rattle. They run smoothly and quietly without the attention which other bearings must have.

3. Facilitates assembly. Ordinarily an awkward operation, this blind assembly is made much easier through the use of a Hyatt bearing.

4. Assures long life. Rust, corrosion and wear are kept to a minimum.

5. Reduces cost. The saving in anti-friction bearing cost will merit your investigation.

Solve your clutch pilot problem by using a Hyatt bearing at this location.

HYATT ROLLER BEARING COMPANY

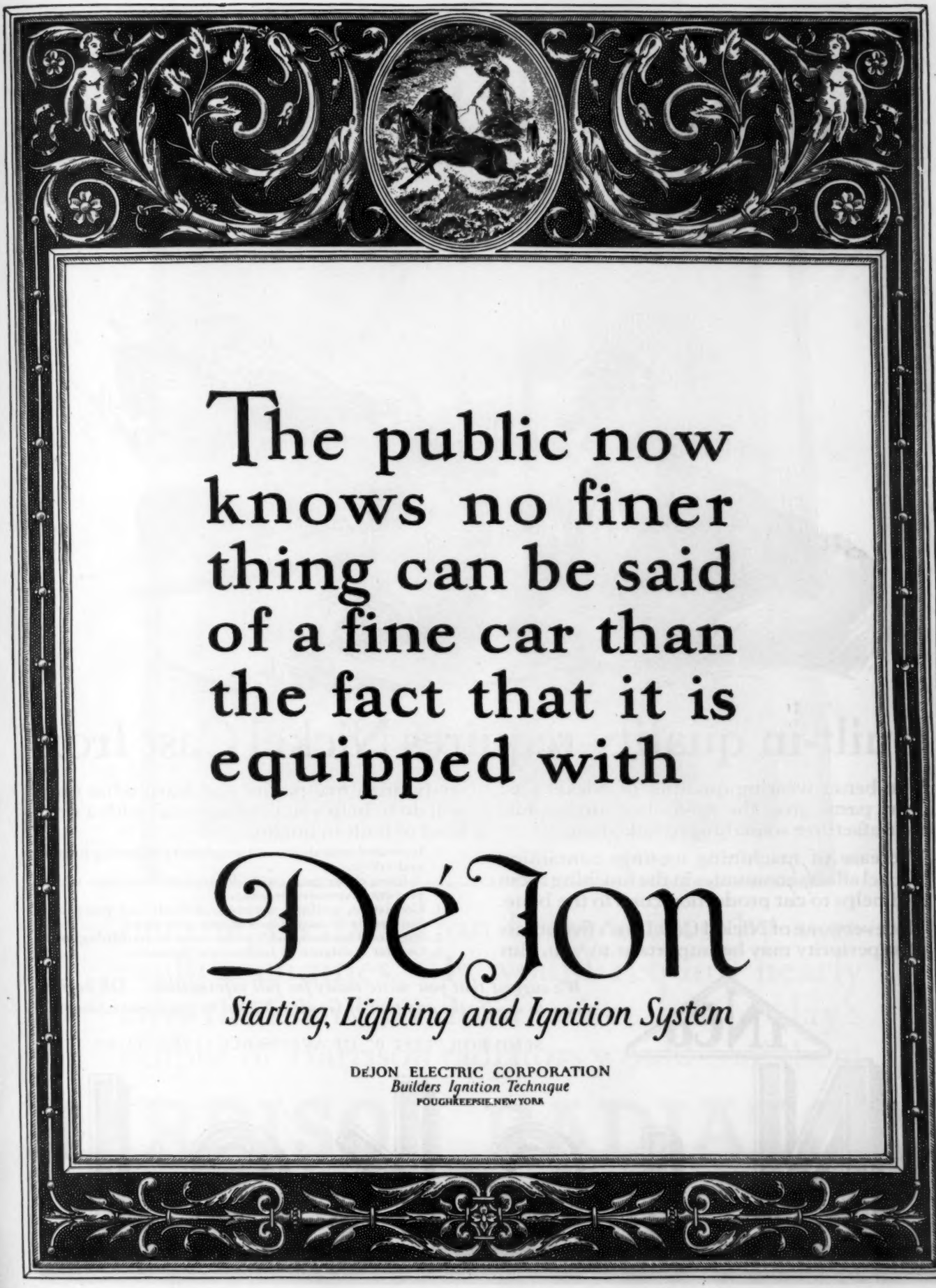
NEWARK DETROIT CHICAGO SAN FRANCISCO

MILWAUKEE WORCESTER CLEVELAND PITTSBURGH PHILADELPHIA

HYATT

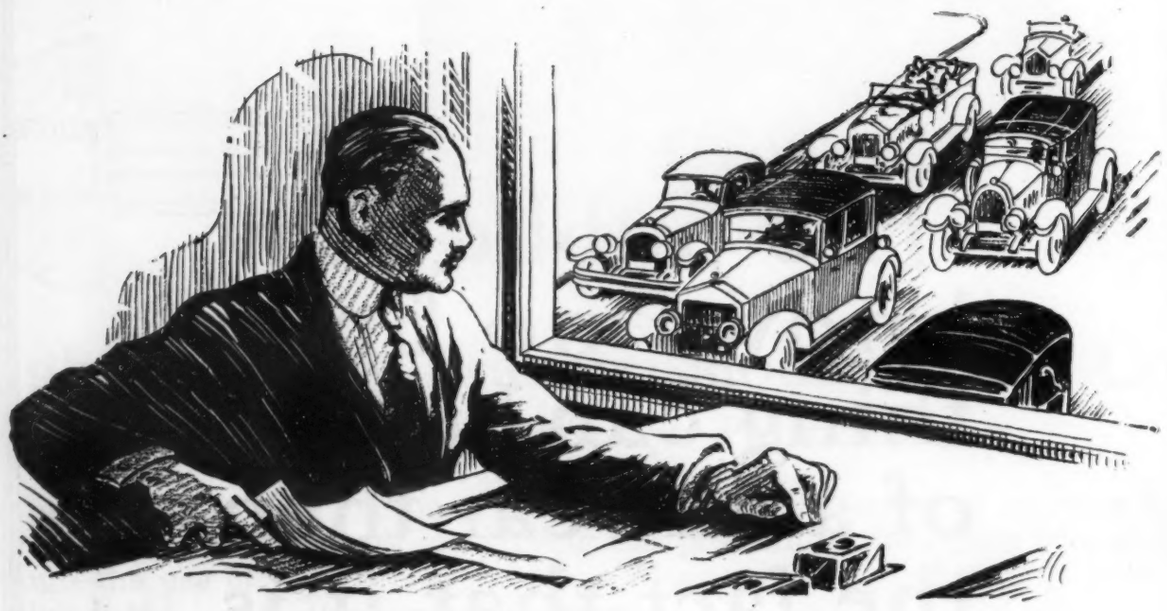
Quiet

Roller Bearings


The public now knows no finer thing can be said of a fine car than the fact that it is equipped with
DéJon
Starting, Lighting and Ignition System
DéJON ELECTRIC CORPORATION
Builders Ignition Technique
POUGHKEEPSIE, NEW YORK

Which car will he choose?

What do buyers look for in automobiles? Every manufacturer is confronted with that question. The growing sales volume of cars with built-in quality proves that the well posted buyer looks beneath the bright colored paint and chooses built-in quality.



Built-in quality requires Nickel Cast Iron

The better wearing qualities of Nickel Cast Iron parts give the up-to-date automobile manufacturer something to talk about.

The ease of machining castings containing Nickel effects economies in the finishing room and helps to cut production costs to the bone.

Not every one of Nickel Cast Iron's five points of superiority may be important to you. But study these five points and learn what they will do to help you produce a car with a new kind of built-in quality.

1. Increased wearability and toughness amounting to 50% and 100%.
2. A finer, closer grain, with diminished brittleness which prevents expensive breakage.
3. Consistent, uniform grayness, difficult and practically impossible to secure in ordinary gray iron.
4. Increased hardness, with no increase in machining costs.
5. Greater resistance to hydrostatic pressures.

We suggest that you write today for full information—OR begin now to specify the addition of Grade F Nickel to gray iron castings.

SEND FOR "LIST B" OF AVAILABLE LITERATURE

INCo Nickel

THE INTERNATIONAL NICKEL COMPANY, 67 WALL STREET, NEW YORK CITY.

Imagine the Leviathan being driven by automobile engines. It would require nearly two thousand to do it. Yet half a day's output of Harrison radiators would cool them.

HARRISON RADIATORS

HARRISON RADIATOR CORPORATION, LOCKPORT, NEW YORK

HARRISON COOLED

THE MARK OF RADIATOR SATISFACTION

MORSE

SILENT CHAINS

Have set a pace for precision and performance which is hard to equal.

Made by manufacturers of power chains for thirty-one years—and designed by automobile engineers of more than 20 years experience it is little wonder that Morse Chains predominate in the front end drive of automobiles.

Morse Chains are the original genuine Silent Chains and are used in 90% of all cars using chain front end drives.

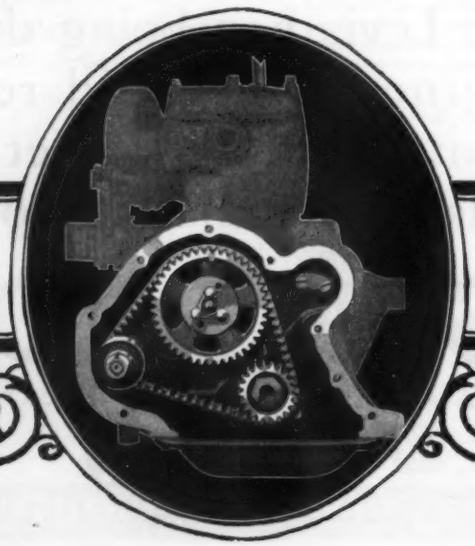
Morse Chain Standard Installations

Anderson Six	Eagle Four	Packard Six
Auburn Six	Essex Six	Packard Eight
Barley Six	Flint Six	Peerless Six
Cadillac Eight	Fox Six	Rickenbacker Six
Case Six	Hupmobile Four	Stearns Four
Chalmers Six	Hudson Six	Stearns Six
Chandler Six	Jordan Six	Sterling-Knight Six
Chrysler Six	Lafayette Eight	Studebaker Light Six
Cleveland Six	Lincoln Eight	Star Four
Columbia Six	Moon Light Six	Templar Four
Crawford Six	National Six	Winton Six
Davis Six	Northway Four	Continental Motors
	Oakland Six	

MORSE CHAIN COMPANY

Main Office and Works
ITHACA, NEW YORK

Sales and Engineering Office
DETROIT, - MICHIGAN



MORSE GENUINE SILENT CHAINS

Carrying Heavy, Precious Loads Over Long Hauls *Smoothly, Swiftly, Safely—*

No matter how heavy and valuable the load or how long the haul may be, you will get there quicker and with greater safety if your trucks are equipped with Dayton Steel Wheels.

Dayton Steel Wheels enable the truck to produce its maximum speed and pulling power, up grades, through heavy roads and on slippery streets—places where ordinary wheels would weaken under the shocks, rubs and knocks that a heavy, speeding truck is sure to receive.

Dayton Steel Wheels are built to withstand heavy lateral strains and violent side thrusts. There is no danger of broken spokes from side-swaying impacts in ruts, car tracks or against curbs and walls.

Dayton Steel Wheels are permanently true round. They cannot develop "flats." Tires will not become loose on the rim. A wheel that is always true round will never exert a drag on the motor or rub the life out of the tire.

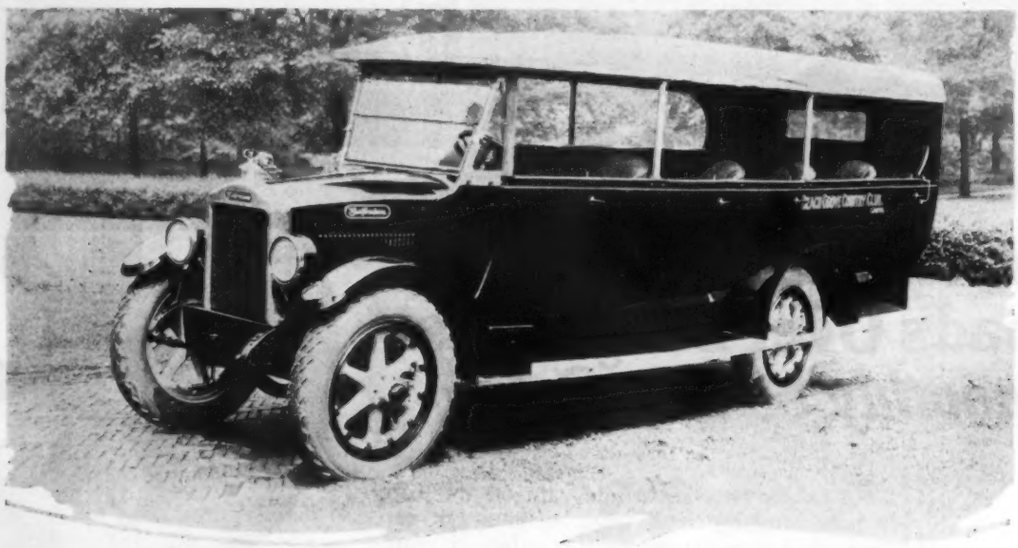
The records of fleet owners prove that Dayton Steel Wheels increase the life and the earning capacity of trucks. A good truck is worthy of a good wheel. Don't overlook the importance of specifying this superior wheel equipment for your trucks.

Built for solid and pneumatic tires and for any standard type front or rear axle.

The Dayton Steel Foundry Co.
Dayton, Ohio

Dayton
Steel Truck Wheels
PATENTED

SKF



On Time Service Always
With Skayef Equipped Motor Buses

TRIP after trip, always on time without any waits or annoying delays, that's the type of service expected from buses. And the operators of bus transportation lines know the good will of passengers and profitable operation depend on utmost reliability of equipment.

The Skayef Self-Aligning Ball Bearing used for the center support of the propeller shaft on this bus stands up under the jolts and jars of rough going without developing wear and compensates automatically for any "whip" without binding or setting up internal strains.

THE SKAYEF BALL BEARING COMPANY
Supervised by SKF INDUSTRIES, INC., 165 Broadway, New York City

1271

Normal View *Deflected View*

Long Trouble-Free Service

It is a noteworthy fact that no manufacturer who has once equipped his car with the Long Clutch has ever adopted any other make.

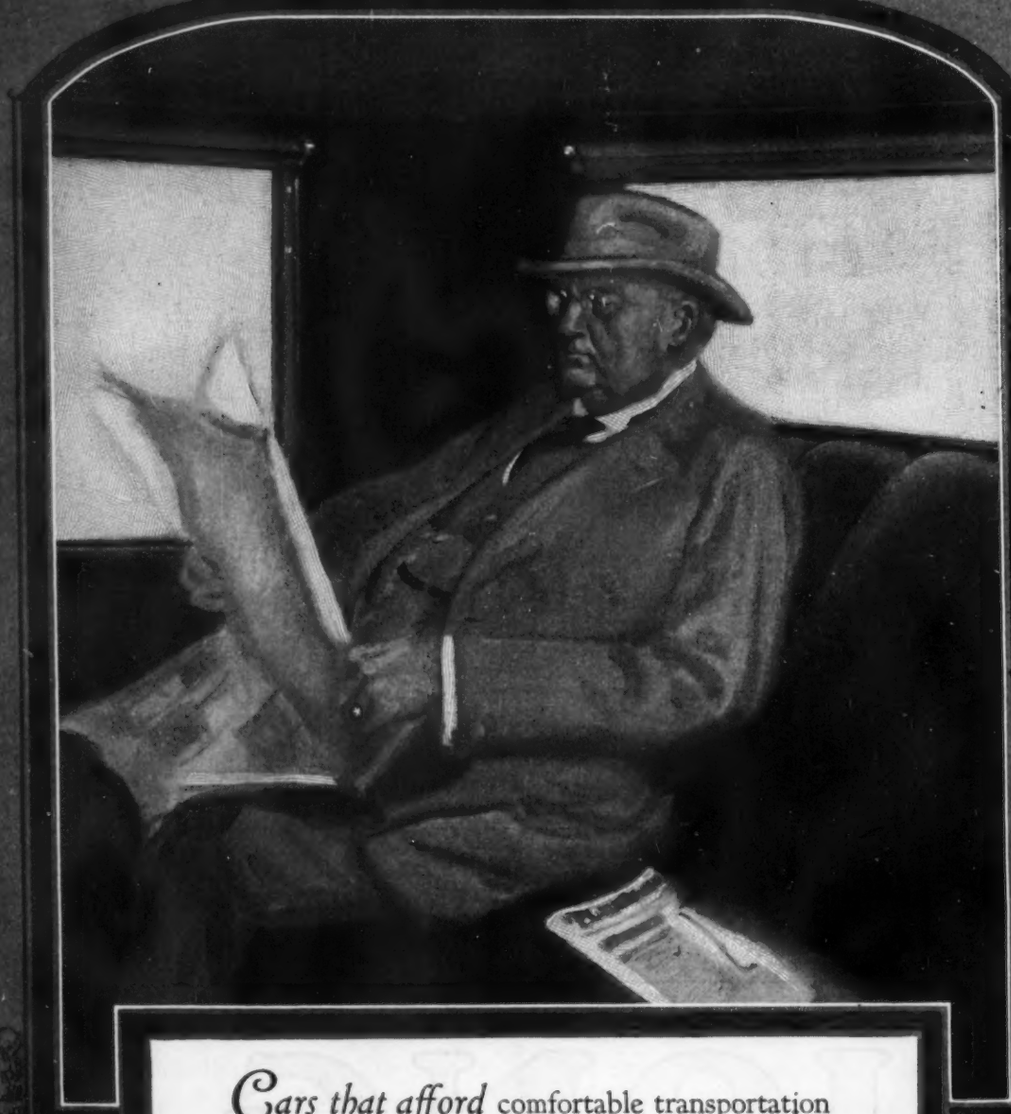
This conclusively proves the ability of Long Clutches to stand constant strain and wear.

LONG MANUFACTURING COMPANY
DETROIT MICHIGAN

LONG CLUTCH

LONG PRODUCTS — RADIATORS AND CLUTCHES

SMITH FRAMES



Cars that afford comfortable transportation over every mile of a long life, free from rattling windows, body squeaks, and binding doors, are built on frames of correct design. While few motorists realize this, there is a moral in the fact that *successful* car builders do.

A. O. SMITH CORPORATION
Milwaukee, Wisconsin
DETROIT OFFICE · 708 FORD BUILDING

Smith
MILWAUKEE

TEETOR
Perfect Circle
PISTON RINGS

It Takes Both

Each has its part but neither will handle the job alone.

(One to a Piston)

(Patented March 29, 1910 - May 2, 1922)

INDIANA PISTON RING COMPANY, HAGERSTOWN, INDIANA, U. S. A.

J. H. TEETOR, *President* C. N. TEETOR, *Vice President & General Manager*

PERFECT CIRCLE

Oil-Regulating Piston Rings

TIMKEN

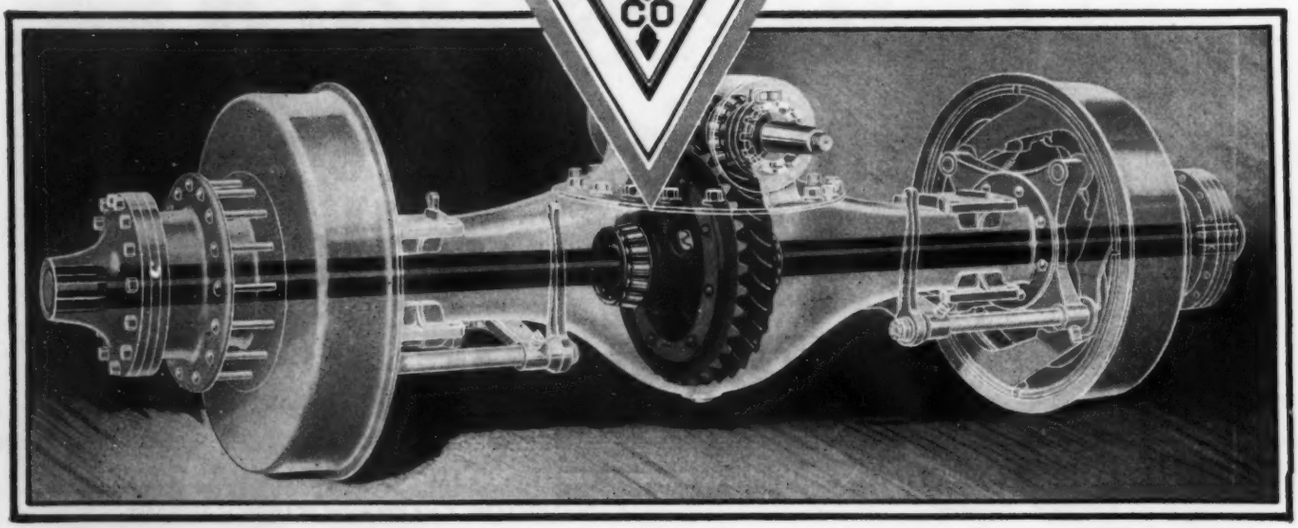
Oil is the Axle's Life-Blood

What clean, rich blood is to a living being, a continuous circulation of good, clean oil is to a rear axle.

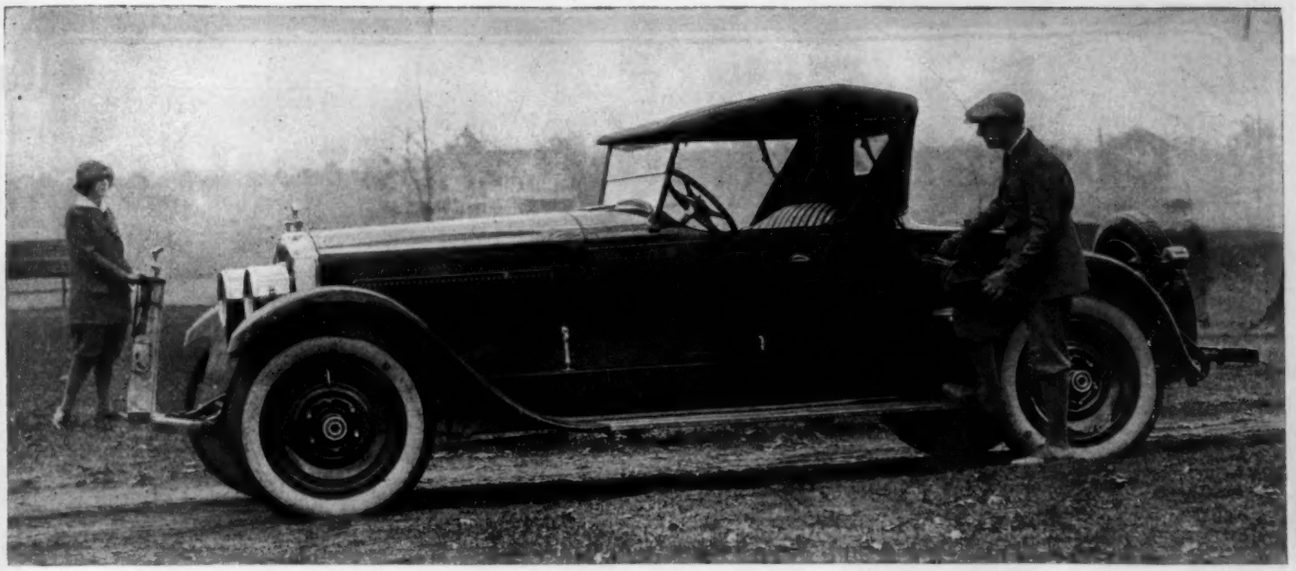
Timken-Detroit Worm Drive construction keeps the oil flowing and keeps the dirt, dust and grit out.

Therefore, be sure you use the *right* oil—it's all you have to do to get continuous, economical operation with a Timken Worm-Drive Axle.

THE TIMKEN-DETROIT
AXLE COMPANY
Detroit, Michigan



AXLES



Double-acting thrust bearing, flat seats (grooved races) 2100-F Series

Single-acting thrust bearing, flat seats (grooved races) 1100-F Series

Single-acting, self-aligning thrust bearing 1100 Series

Single-acting, self-aligning thrust bearing, leveling washer. 1100-U Series

Double-acting, self-aligning thrust bearing, leveling washers 2100-U Series

Motor Car Manufacturers

Who Build for Permanent Satisfaction Use

Strom Ball Bearings

WHEN a motor car manufacturer takes such pride in his product that his slogan says *"Ask the man who owns one,"* you know that every part that goes into the making of that car is the very best that can be obtained.

Strom Ball Bearings are standard equipment on all Packards because they insure easy and noiseless operation of moving parts. Long, continuous service has no effect on them.

Ask any owner of a Packard Six or Eight.

Strom BALL BEARINGS

STROM BALL BEARING MFG. CO.
Formerly U. S. Ball Bearing Mfg. Co.
4533 Palmer St., Chicago, Ill.

Single-row deep-groove Standard type, radial bearing

Double-row, deep-groove Standard type, radial bearing

Angular contact bearing, combination radial and thrust

Double-row, maximum type, radial bearing

Single-row, maximum type, radial bearing

Chrome-Vanadium Steel In Rickenbacker Motor Cars

CLUTCH and valve springs, gears, motor supports, front axle and brake parts of Rickenbacker Motor Cars are made of Chrome-Vanadium Steel.

"Our tests of clutch and valve springs," writes the Rickenbacker Experimental Department, "show that straight carbon steel loses one-third its strength when compressed for a length of time sufficient to cause less than 5 per cent change in the Chrome-Vanadium Steels we use.

"We have never had a failure in a Chrome-Vanadium front axle part where fatigue caused straight carbon steel to fail.

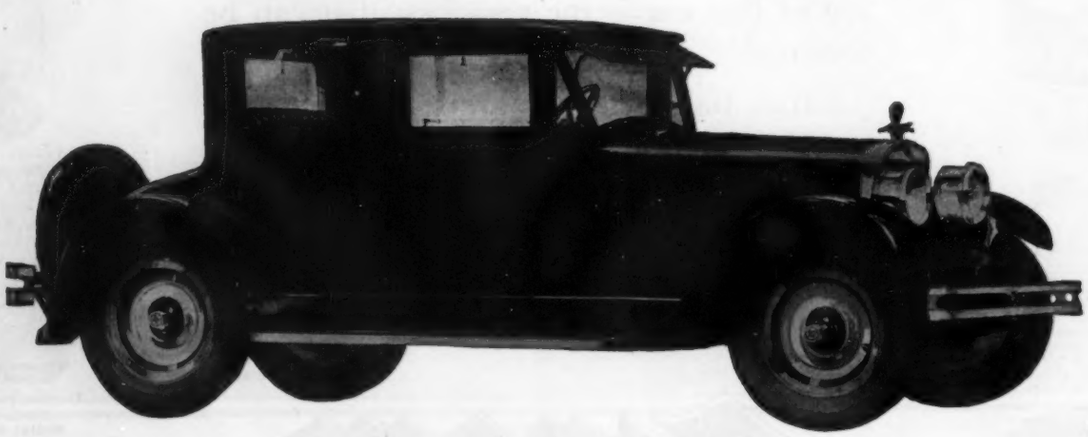
"On gears we use Chrome-Vanadium Steel interchangeably with straight carbon steel. We have encountered no difficulty with either."

If you seek to improve the quality of steel parts, ask for the suggestions of our metallurgists. Their service is given freely to all users of steel.

VANADIUM CORPORATION OF AMERICA

NEW YORK
120 Broadway

DETROIT
Book Bldg.



VANADIUM STEELS

for Strength, Toughness and Durability

After 80 Years

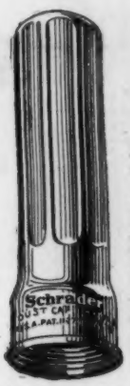
THE business of A. Schrader's Son, Inc., is eighty years old. It is applying today, for tire maker and motorist, the lessons learned during these years of experience in the manufacture of equipment for confining air.

Fifty years before the first automobile ran, August Schrader founded in New York the business that now bears his name. He began by making diving suits which he equipped with pneumatic valves.

Founded in 1844, the history of the Schrader Company covers the successful confinement of air by Schrader Valves in air beds, air pillows and cushions and other pneumatic products. With the coming of pneumatic tires, Schrader made tire valves. From the first these tire valves successfully held air.

Today, Schrader Tire Valves are standard equipment on practically all bicycle, motorcycle, truck and automobile tires made in the United States and Canada. Careful workmanship, rigid inspections, countless tests and experiments have always insured their dependability. This unerring accuracy in manufacture makes possible interchangeability of parts.

Use Schrader Tire Valves and Valve Parts on all pneumatic tires. They help your tires give the full service that you put into them. Manufacturers and supply houses can always rely on prompt shipment from our large stocks.



This is the Schrader Tire Valve complete with all its parts.

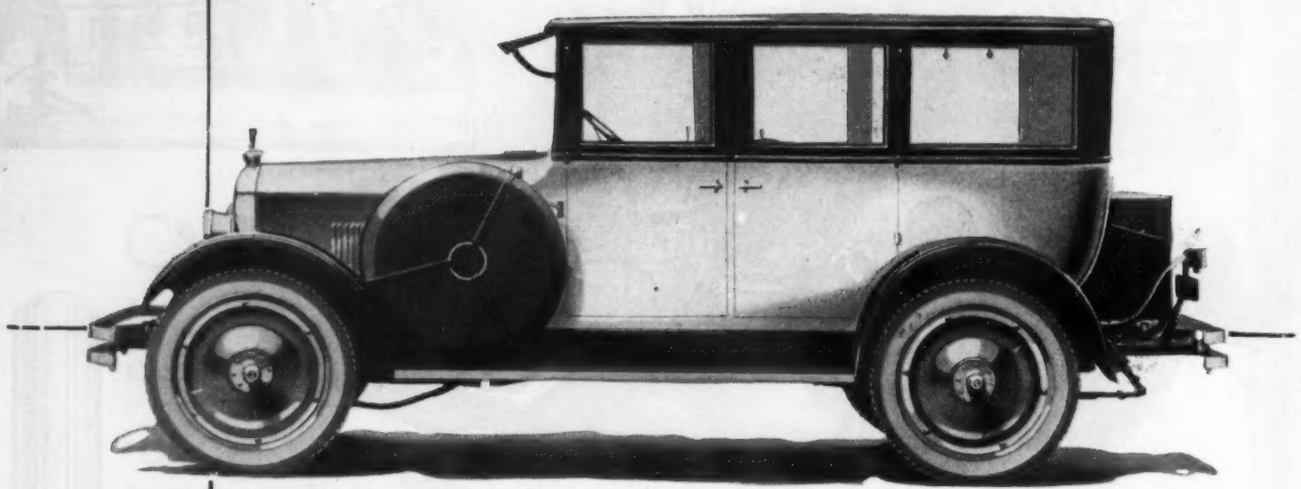
Be sure it's a Schrader—buyers, look for the name!

A. SCHRADER'S SON, Inc., Brooklyn, N. Y.
Chicago Toronto London

Schrader

Makers of Pneumatic Valves Since 1844

Tire Valves · Tire Gauges



JEWETT

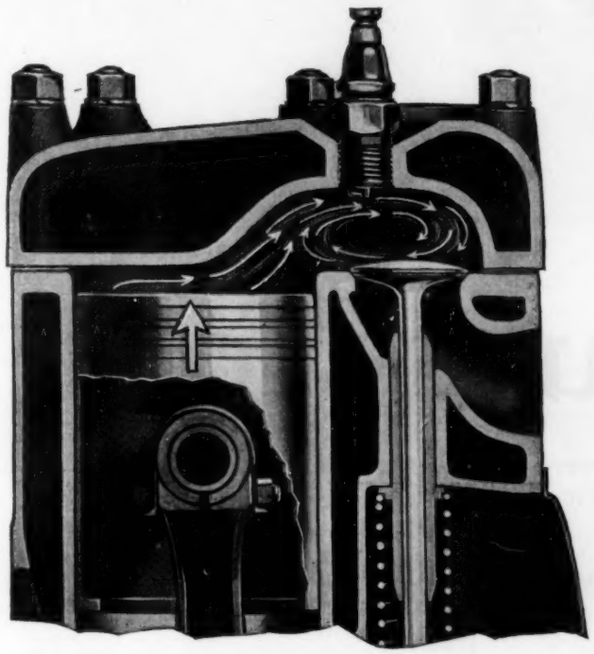
is satisfied with

WESTINGHOUSE
BATTERIES

WESTINGHOUSE UNION BATTERY CO.
Swissvale, Pa.

The Ricardo Head

Abolishes Fuel Knock



No modern engine operating under practical conditions knocks when using ordinary fuels.

This is the achievement of the Ricardo Head.

United States Patent granted Nov. 13, 1923, to Waukesha Motor Company as assignee of Harry Ralph Ricardo, the English scientist.

Waukesha Motor Company

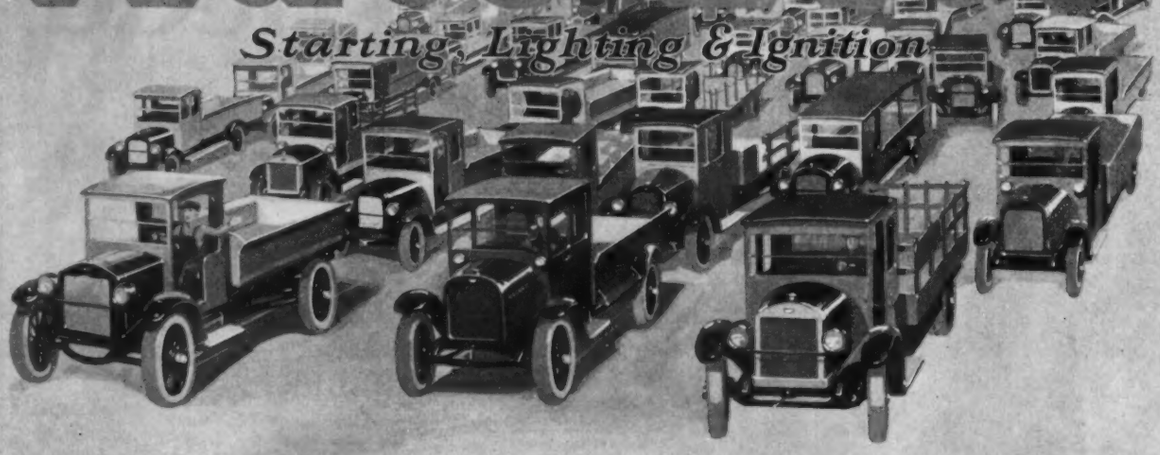
Engine Builders

Waukesha **Wisconsin**

NEW YORK CITY

Auto-Lite

Starting, Lighting & Ignition



On Trucks Too!

Trucks impose the most severe requirements upon an electrical system.

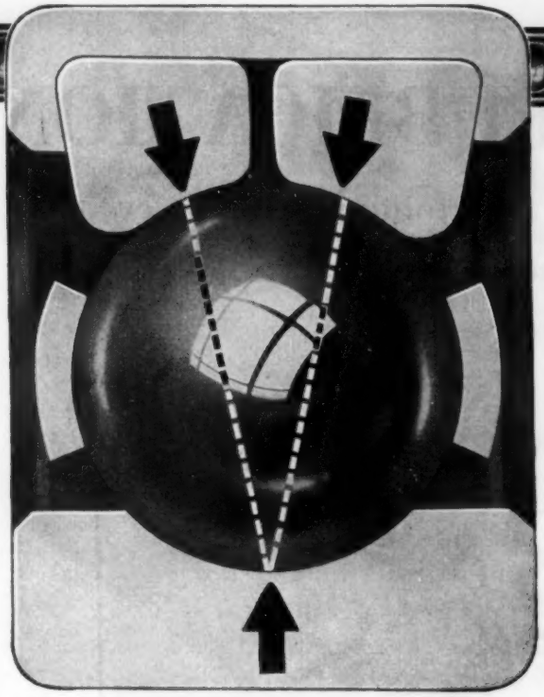
To serve them satisfactorily is the supreme test of hard work, economy and dependability.

The Auto-Lite starting, lighting and ignition system meets this test so completely and satisfactorily that an increasing number of trucks are adopting it as equipment.

Acme	Federal-Knight	Overland Spad
Betz	Garford	Republic
Biederman	Gramm-Bernstein	Sandow
Butler	Indiana	Star Delivery
Chicago	International Harvester	Tow Motor
Dart	Mason Road King	Trabold
Denby	Moreland	Victor
Diamond T	Nash	Ward LaFrance
Durant	Oshkosh	

THE ELECTRIC AUTO-LITE COMPANY

Office and Works — Toledo, Ohio.



—no other bearing like this!

AS fixed as the three legs of a triangle, on whose basic principle of rigidity it operates, the Schatz "Universal" Annular Ball Bearing is capable of withstanding great radial and thrust loads. Its ability to operate efficiently under stress is due to the three area contact, an exclusive feature which eliminates direct blows to the balls, while increasing the supporting area.

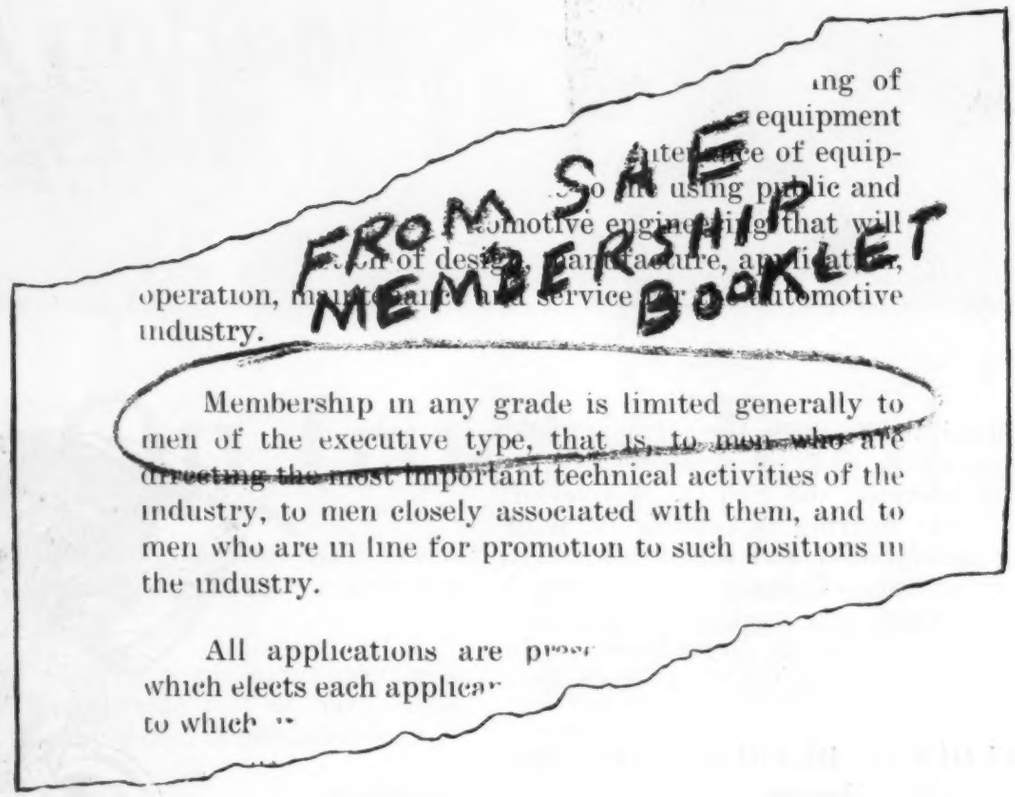
THE FEDERAL BEARINGS CO., Inc.
Poughkeepsie, N. Y.

Schatz "UNIVERSAL" Registered U.S.Pat.Off. Annular BALL BEARING

ADAPTABILITY

A REAL CLASS PUBLICATION

The Journal of the Society of Automotive Engineers is mailed to more than 5500 men who hold responsible positions in the Automotive Industry.



ing of
equipment
ce of equip-
using public and
automotive engineering that will
of design, manufacture, application,
operation, maintenance and service in the automotive
industry.

Membership in any grade is limited generally to men of the executive type, that is, to men who are directing the most important technical activities of the industry, to men closely associated with them, and to men who are in line for promotion to such positions in the industry.

All applications are pre
which elects each applica
to which

NO WASTE CIRCULATION

If you wish to tell your story to the Automotive Industry tell it to the S. A. E. through the advertising pages of

The Journal of the Society of Automotive Engineers

RATES ON APPLICATION.

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.
29 W. 39th STREET, NEW YORK

Charged

TRADE MARK
bone dry
REGISTERED

—The greatest advantage

Just pour in the solution and that's all

All the life of the Willard Charged Bone-Dry Battery goes to the man who buys it.

Everybody shares this advantage. *Car builders*, because there are no partly worn out batteries on new cars. *Car dealers*, because battery newness can be proved to car buyers. *The Car buyer* because he knows he's getting full value.

A storage battery *starts* its life on the day it is filled. The Willard Charged Bone-Dry Battery is the only automobile battery which does not have to be filled until the owner is ready to use it.

To prepare a Willard Charged Bone-Dry Battery for service you just pour in the battery solution—and that's all!

WILLARD STORAGE BATTERY COMPANY, CLEVELAND, OHIO
In *Canada*: Willard Storage Battery Company of Canada, Limited, Toronto, Ontario

WTAM, "The Voice of the Storage Battery", is Willard's own Radio Research Laboratory and Broadcasting Station. Wave length, 390 meters.

Willard STORAGE BATTERIES

TRADE MARK BB REG. U.S. PAT. OFF.

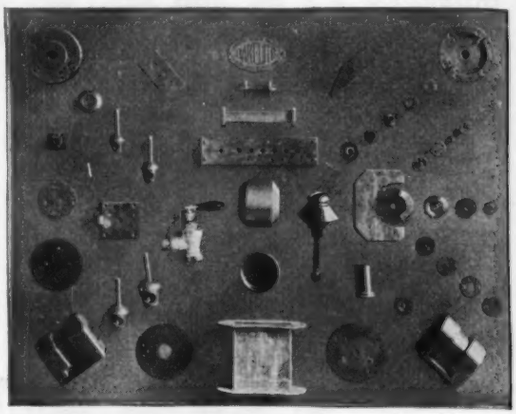
"Symbol of Quality"

BOONTON BAKELITE first opened the way to low-loss parts at low prices

BOONTON BAKELITE
has always meant
Genuine Bakelite

Low prices for parts of low-loss insulating material may be had in one way only. Specify *genuine* Bakelite, molded by people who started the industry. Their experience—15 years—cuts the cost of molds, saves waste of raw materials, and guarantees each piece for satisfactory service.

New booklet tells why—Send for it.



The first Bakelite parts molded at Boonton in 1909.

BOONTON RUBBER MFG. CO.
Pioneers in Bakelite Moulding
722 Fanny Road, Boonton, N. J.

DAHLSTROM
Metal Mouldings & Shapes

DAHLSTROM
Windshield Tubing

Dahlstrom Windshield Tubings are drawn from the best grade cold rolled strip steel. Each process of manufacture is carefully carried out. They may be shipped cut, mitred, punched and tapped for screws. Finished by our baked-on-enamel process or in unfinished mill lengths as desired.

DAHLSTROM METALLIC DOOR COMPANY

435 Buffalo Street, Jamestown, New York

PHILADELPHIA 305 Bulletin Bldg. DETROIT 501 Capitol Theatre Bldg. CHICAGO 19 S. La Salle St.

Have We Your Correct Address?

The New York Office is just as anxious as the individual members that they receive THE JOURNAL and other communications promptly.

This result cannot be achieved unless

Members notify the office whenever they make a change in their business connection or their mail address or both.

Members who have been in the service of the Government either as civilians or in the Army or Navy will please let us know when they leave the service and also when they re-enter commercial fields.

Your cooperation is necessary and will be greatly appreciated.

May We Have It?

SOCIETY OF AUTOMOTIVE ENGINEERS, Inc.

The continuous associations of an institution reflect its true character

UNION DRAWN STEEL COMPANY

Warehouses: New York Philadelphia Chicago Cincinnati Detroit

Sales Offices: Boston Buffalo Cleveland Milton Pray Co.: Los Angeles, San Francisco, Seattle

Mills: Beaver Falls, Pa. Gary, Ind.

BEAVER FALLS PA

NATIONAL
RADIATORS

Here is probably America's most famous radiator—the National. Both the Zig-Zag Circular and Spiral Tube Nationals are found on some of the best known passenger cars, trucks and tractors. This is significant and should be very indicative to you. Quality cars require quality units. When it comes to the radiator—select the National.

NATIONAL RADIATOR & MFG. CORPORATION
Formerly National Can Corporation
Detroit **Michigan**

OLSEN TESTING MACHINES

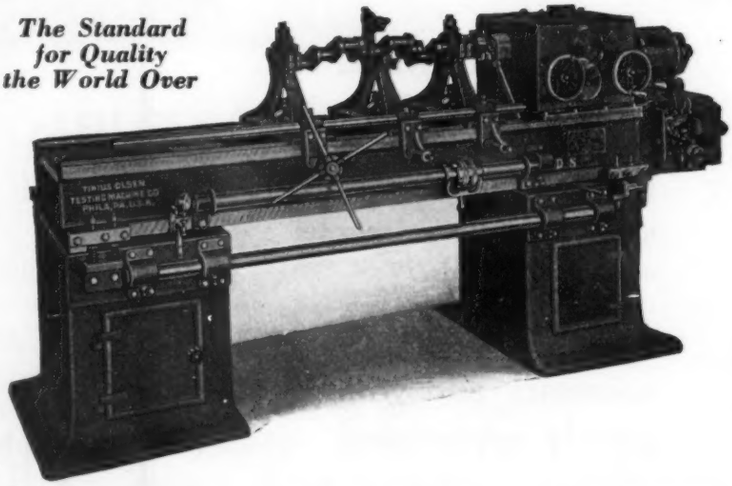
UNIVERSAL TESTING MACHINES for tension, compression and transverse tests of all metals and materials.

HARDNESS TESTING MACHINES for Brinell Hardness tests of all material including sheet metal.

DUCTILITY TESTING MACHINES for determining drawing quality of sheet metal. CEMENT, CONCRETE, CHAIN, ANCHOR, WIRE, ROPE, OIL, PAPER, CLOTH and Rubber Testing Machines.

TORSION, IMPACT, REPEATED IMPACT, TOUGHNESS, ENDURANCE, WEAR, ALTERNATE STRESS and EFFICIENCY Testing Machines.

The Standard for Quality the World Over



OLSEN-CARWEN STATIC-DYNAMIC BALANCING MACHINES

Eliminate Vibration—Secure Perfect Balance with Speed and Economy

The Olsen-Carwen is made in many sizes and types to balance any rotating parts from the smallest to the largest rotor made. Now used by all the leading up-to-date automobile and motor manufacturers throughout the country.

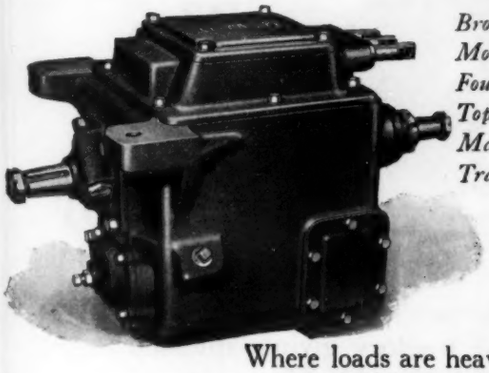
SOLE MANUFACTURERS

TINIUS OLSEN TESTING MACHINE COMPANY

500 NORTH TWELFTH STREET
PHILADELPHIA, PA., U. S. A.

FOREIGN REPRESENTATIVES—*Messrs. R. S. Stokvis & Fils, Paris, France, Brussels, Belgium, Rotterdam and Amsterdam, Holland. Edw. G. Herbert, Ltd., Manchester, Eng. Andrews & George Company, Tokyo, Japan.*

A Giant Among Transmissions



Brown-Lipe Gear
Model 60
Four-Speed
Top Shift
Main Frame
Transmission

Where loads are heavy and roads are rough this model transmission proves its great worth.

Only accident or misuse will stop its quiet, efficient operation, and then new, genuine parts are quickly obtainable.

Complete information on this and all other Models given on request.

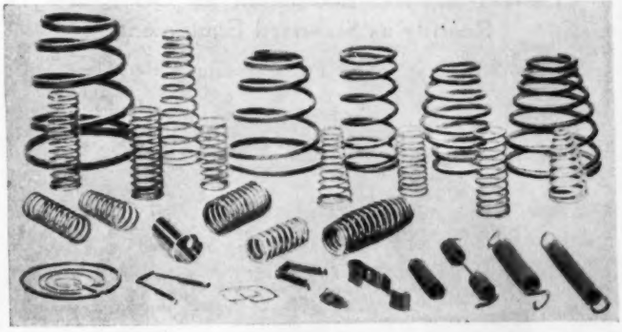
BROWN-LIPE GEAR CO.

BROWN-LIPE GEAR COMPANY

SYRACUSE, N. Y.

San Francisco Chicago Detroit New York London, Eng

SPRINGS



Few realize, even among engineers, how much of engineering design, proper calculation of stresses, metallographic selection of materials, and scientific heat treatment, is involved in the production of a high grade spring—

We realize all these things—AND DO THEM.

THE WM. D. GIBSON CO.
1800-1824 CLYBOURN AVENUE
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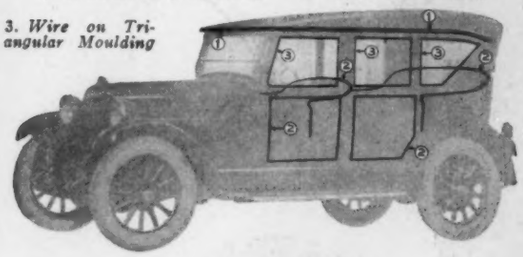
Manufacturers of All Types of Springs
Compression—Extension—Flat—Torsion

Any Size Any Material

Send for our treatise on springs.

1. *Wire on Drip Moulding* 2. *Wire on Moulding*
3. *Wire on Triangular Moulding*



Distinction —with Economy

Wire On Products enable the manufacturer to obtain distinctive, individual effects—and at the same time keep the cost down to the minimum. Supplied in cones containing multiples of the exact length required for each job, hence no waste. Costs less than metal mouldings, and can be applied by one man.

Drip Moulding

Wire On Drip Moulding fills a practical need in finishing closed car exteriors. Costs less than quality metal mouldings, and can be applied by one man. Only one finishing operation is required, and all moulding waste is eliminated.

Wire on Moulding

Wire On Moulding is applied in half the time required for ordinary welts. One edge is tacked, the other half-round, folds over concealing the tack heads. Made from any specified material to match or harmonize with any upholstery.

Triangular Moulding

No more closed car window rattles. Wire On Triangular Moulding cushions the glass and conforms to it. Fills a long-felt need. Like other Wire On Products, it is easily applied—which means low labor costs.

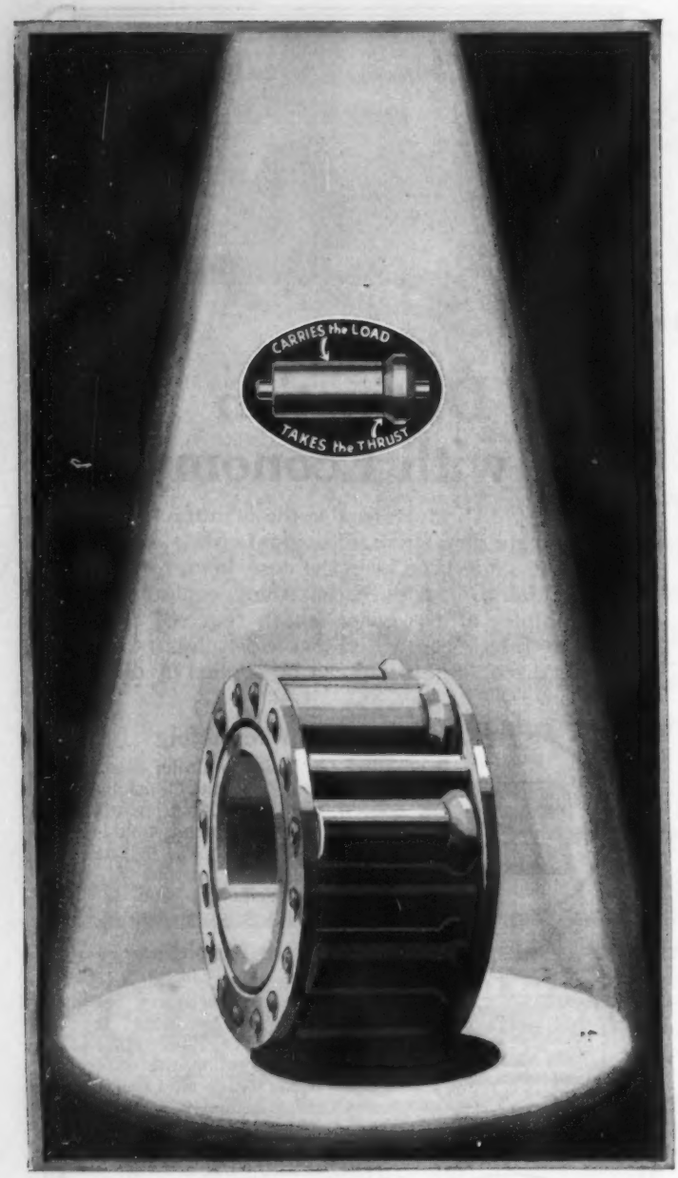
U. S. Patent, Aug. 16, 1921; Canada Patent, July 25, 1922.
Additional and Foreign Patent Pending.

WIRE ON PRODUCTS

The Geo. R. Carter Co.

CONNERSVILLE, INDIANA

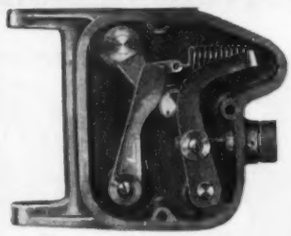
Complete cooperation and assistance are offered manufacturers in working out their trimming problems. Experience gathered since 1896 is at your disposal. Write us for additional information.



WHEN an engineer specifies Bower Roller Bearings for a car or truck, he knows that there is one part he can conscientiously forget. They seem to serve everlastingly with no adjusting or additional service. And to manufacturers, as well as car owners, this is of inestimable value.

BOWER ROLLER BEARING CO.
DETROIT, MICHIGAN

BOWER
ROLLER BEARING CO.
Detroit Michigan



Sectional View showing simple construction

The Handy Governor

Thousands in use on trucks and tractors giving splendid satisfaction.

Made in standard sizes for motors ranging from 100 to 650 cu. in.

Our engineering department will be glad to discuss your governor problem. Literature on request.

Handy Governor Corporation
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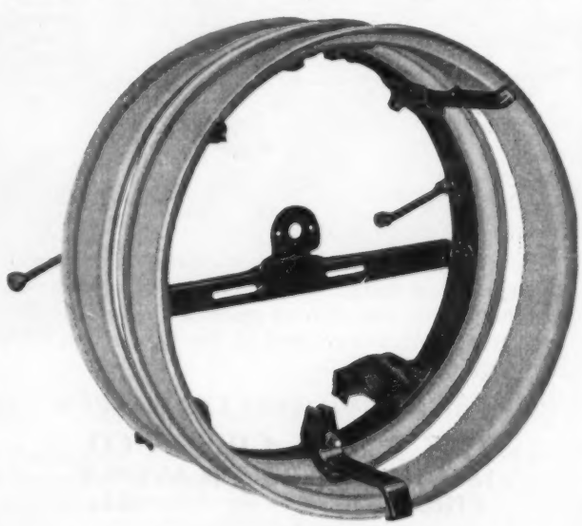
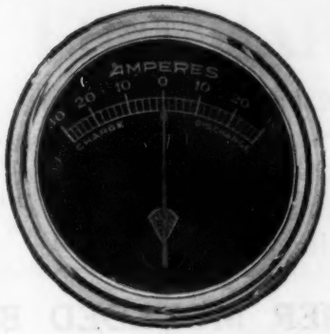
Carries Balloon Equipment as Easily and Readily as Standard Equipment

No Straps or Metal Parts to Chafe the Tires



DETROIT CARRIER & MFG. CO.
DETROIT, U. S. A.



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Nagel ammeters have been standard equipment on six million cars, being designed for automobile use and of rugged construction. True condition of electric system is always obtainable.

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AMMETERS · OIL PRESSURE GAUGES
PANELS · HOT MOULDED INSULATION

THE W.G. NAGEL ELECTRIC CO.
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Small quantities, too, of course. In fact, we have a

SMALL ORDER DEPARTMENT

to make quantities of one spring to a hundred.

Try us on small orders as well as large.
Shipments averaging ten days.

The Wallace Barnes Co.
Bristol, Conn.

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Equipment that produces economy and a lasting finish.

WITH the names of the more popular cars and recognized coach builders is linked the name of Drying Systems, Inc.

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Chandler	Chevrolet
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Special, thoroughly tested steel

AFTER 21 years of open-minded experience in propeller shaft engineering, we have found no material equal to the right kind of steel for every part.

The choice of steel is not left to rule-of-thumb—

Spicer Propeller Shaft

steel is made to specifications covering the service it will be called upon to meet and is analyzed in the laboratory before acceptance.

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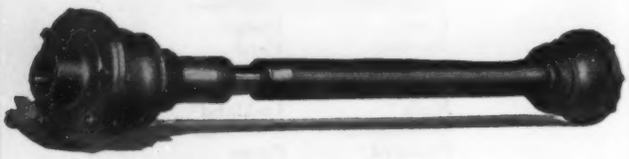

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GILMER MOULDED BELTS

FLAT TYPE and "V" TYPE

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High Compression
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DRIVERS SEAT PEDESTAL with shock absorbing device. Has no springs and requires no oil.

Adjustable in height and also fore-and-aft.

No. 5739

Back designed to be a real support and to allow sufficient elbow room for steering.

Makes the driver as comfortable as the passengers.

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ARM CHAIR PEDESTAL. Strong without excessive weight. Neat appearance, in keeping with all other appointments of a high class body.

THE EBERHARD MANUFACTURING CO.
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Chances are even at any rate that you are getting good springs, promptly and dependably, now. If you would like to get better springs, or want a little more prompt delivery, or a more convenient source, tell us about it.

We believe we can be of real service to the engineer on spring design, and our facilities are at your disposal.

We are equipped to make all types of round wire and small flat springs of any material.

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6400 MILLER AVENUE
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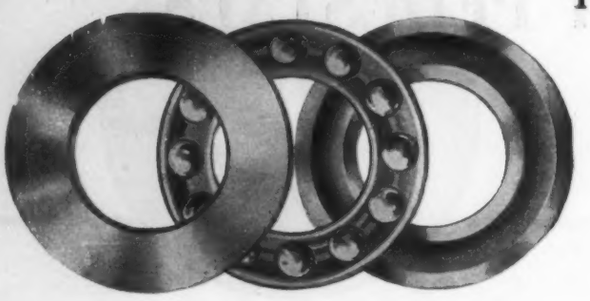

The Bearings Company of America

Your present Thrust Bearings sizes duplicated.
Thrust Ball Bearings made to your B/P's.

Quotations made promptly on all inquiries.

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Western Sales Office
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234 WEST 56th STREET
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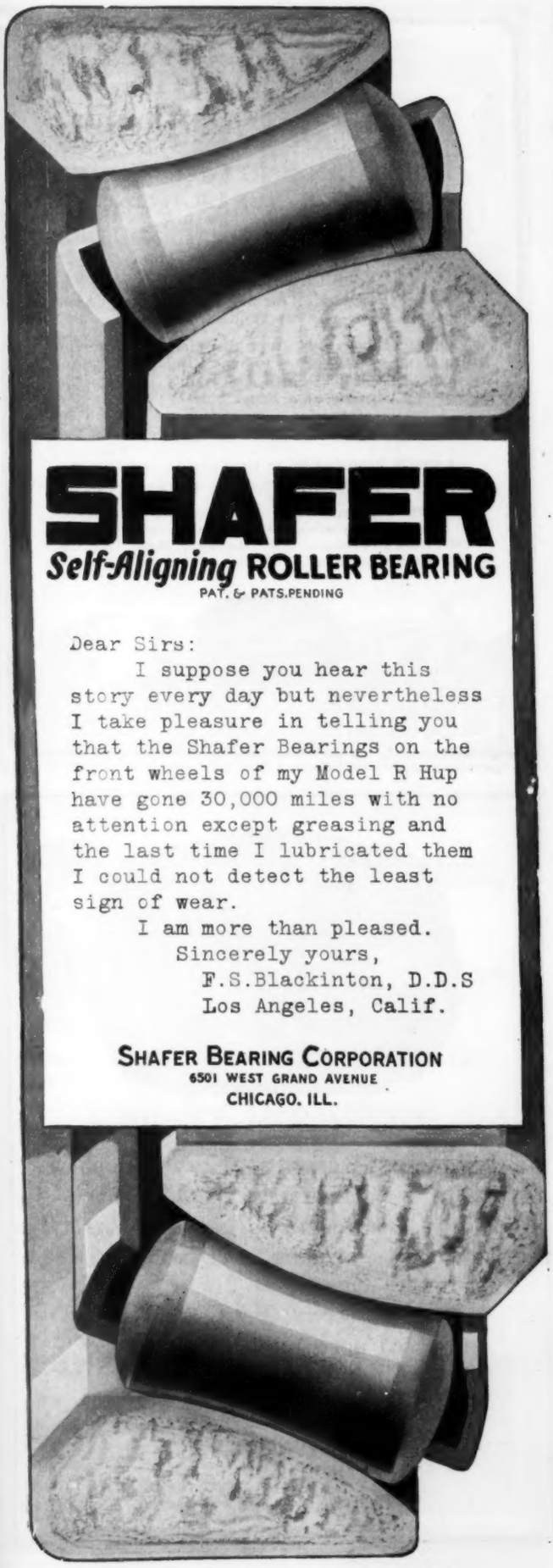
Detroit Representative:
GETSINGER-FOX COMPANY, 3-154 General Motors Bldg.

Mill:
Broad Brook, Conn.

Builders to the most discriminating passenger car and truck manufacturers in the United States and Europe.

STANDARD STEEL SPRING COMPANY
CORAOPOLIS, PA.
MANUFACTURERS of LEAF SPRINGS



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Self-Aligning ROLLER BEARING

PAT. & PATS.PENDING

Dear Sirs:

I suppose you hear this story every day but nevertheless I take pleasure in telling you that the Shafer Bearings on the front wheels of my Model R Hup have gone 30,000 miles with no attention except greasing and the last time I lubricated them I could not detect the least sign of wear.

I am more than pleased.

Sincerely yours,
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Los Angeles, Calif.

SHAFER BEARING CORPORATION
6501 WEST GRAND AVENUE
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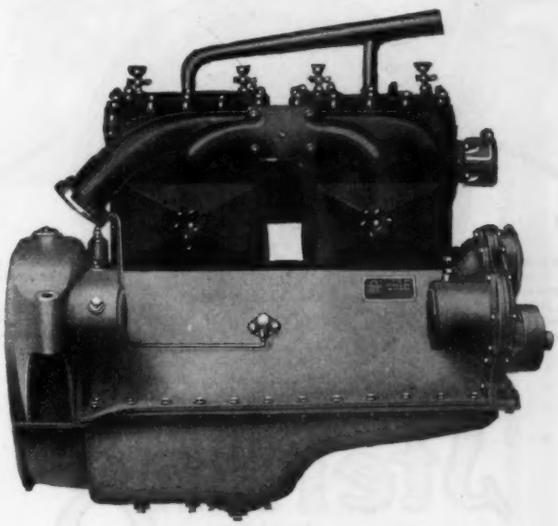

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Manufacturers who equip their products with Hinkley Heavy-Duty Automotive Engines command several sales assets not otherwise available.

One of these assets is the Hinkley Plan which guarantees 100% Engine performance for life, and completely eliminates major overhaul.

Every owner of a Hinkley-Engined unit is eligible to receive the benefits of this Plan. Whenever desired he can, through its provisions, exchange his worn Engine for a fresh, remanufactured Hinkley, thus renewing the life and efficiency of his whole unit.

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A complete line for you to pick from:

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HEAVY DUTY AUTOMOTIVE

ENGINES

Sterling is the largest producer of Dash Ammeters in the world!

Sterling Dash Ammeters are made according to S. A. E. standards.

Sterling

Model 500

DASH AMMETERS

Standard Equipment on many of America's leading cars. Their simple and rugged construction adapts them for long and satisfactory service.

Volume production, long experience, modern daylight plant of fireproof construction, up-to-the-minute special machinery, economical, efficient management, low "overhead" expense, a beautiful thoroughly reliable, time-tested product; these are the advantages which we share with those car manufacturers who make STERLING ammeters standard equipment.

Flush or projecting cases in any style or finish. Etched metal dials finished in black or silver, any scale.

Write for descriptive matter, samples or quotations.

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An OUTSTANDING IMPROVEMENT *in* MOTOR BUS LIGHTING

Voltage Regulation is the *modern* electrical generating system for the modern motor bus.

The Leece-Neville system of Voltage Regulation has been adopted as the standard of the foremost bus and motor rail car builders.

Voltage Regulation gives the motor bus a wide range of operating advantages. It is simple, automatic and trouble-proof. It greatly increases the earning capacity of a motor bus.

Write for our Booklet "Voltage Regulation"

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The White Company — J. G. Brill Car Company
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PERFECT CONTACT IS SECURED ON ANY ANGLE

More Than Two Million in Use

The General Phonograph Mfg. Co.

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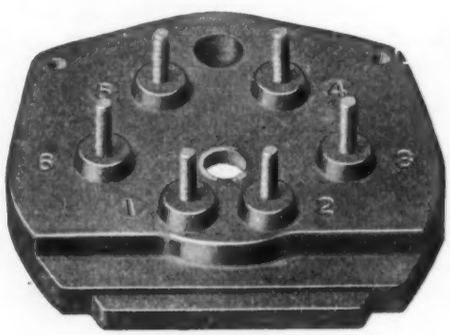

The new plant of the International Insulating Corporation, now located at Elyria, Ohio, has been completed and is in production on gear shift lever balls, distributor heads, radiator caps, electrical connections, and all moulded parts, either from shellac composition or synthetic material, used on automobiles.

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Highland Cab

A universal unit, meeting every trucking condition. Wide open for summer use—partly or completely closed for use in winter or stormy weather.

Made in sizes to fit any truck and every driver.

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The Magneto
That Made the Name
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Famous

A type for every engine.
Over 3,000,000 in use.

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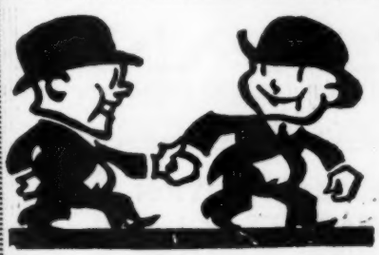

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is right on its toes with good estimates, quick but neat handling, and accurate sizes, composition and soundness in all Non-Ferrous Metal Castings. And their

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Or better still send them your samples or blue prints. They're glad to estimate. Just address them to the

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VENUS

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The 17 black degrees of
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meet every pencil demand—with superlative smoothness. For drafting, sketching and writing, they are the world's accepted standard.

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Starting Lighting Ignition — *Horns Speedometers*

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Starter-Generators Starting Motors
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Raymond Springs

of Carbon or Vanadium Steel; Brass or Bronze

We are specialists in designing, manufacturing and testing wire springs for accurate and dependable operation.

Write Raymond for Reliable Springs.

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What your inquiry brings back

YOUR inquiry to Interstate brings back accurate information, based upon the experience of our metallurgists. Exact promise of delivery from the calculations of our mill executives. And if Interstate is known to you, it brings back something more—the unafraid assurance that the job will be well done.

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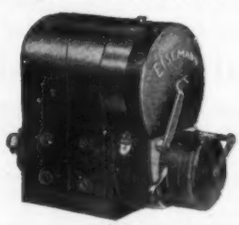
ELECTRICAL EQUIPMENT

EISEMANN IGNITION APPARATUS for 1, 2, 4 and 6 cylinder engines is unexcelled for its correct design; accurate and careful workmanship and unfailing performance, even under the severest working conditions.

Inquiries solicited



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General Offices: 165 Broadway, New York
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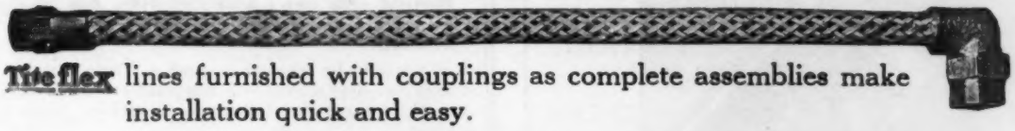
Titeflex Oil, Water and Gasoline Lines for Automobiles, Trucks and Tractors.

500,000

TITEFLEX LINES INSTALLED IN THIS SERVICE.



Titeflex lines furnished with couplings as complete assemblies make installation quick and easy.

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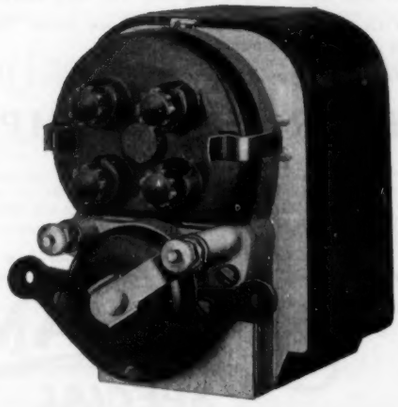

SIMPLICITY-RUGGEDNESS
EFFICIENCY-RELIABILITY

Conforms to S. A. E. Standards

Write for Further Information

The Teagle Co.
Cleveland, Ohio

"The Simplest Magneto of Them All"

DROP FORGINGS

Backed by 40 Years Experience

AUTOMOBILE
TRUCK
TRACTOR

Complete Heat Treat and Laboratory Facilities
Capacity 2000 Tons Per Month

UNION SWITCH & SIGNAL CO.
Drop Forge Division
PITTSBURGH DISTRICT SWISSVALE, PA.

See notice on
page 26
regarding S. A. E.
Employment Service

Westinghouse

Ignition
Lighting
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82 Worthington St.
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K.P. is simple and automatic—no complicated parts—durable and efficient.

It positively governs—but *does not* restrict engine power.

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K. P. Products Co., Inc.

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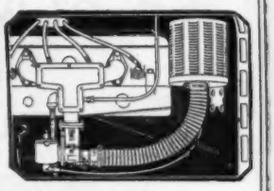
K·P. Governor

GOVERNS WITHOUT LOSS OF POWER

PROTECTOMOTOR

REG. U. S. PAT. OFF.

Perfect Positive Protection



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We would be pleased to send a Protectomotor to the engineering department of any automobile, truck or tractor manufacturer for purposes of making tests to verify our claims.

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We are building axle housings, brake drums, and other parts for the heaviest motor trucks ever built, and have ample capacity for still heavier.

With our complete equipment we cover the entire sheet metal stamping line.

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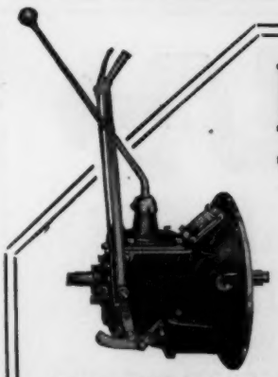

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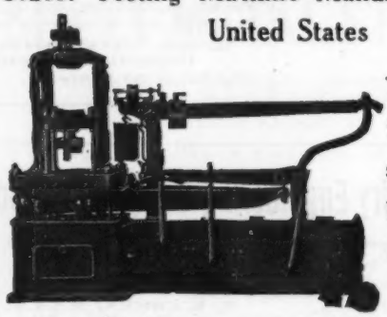

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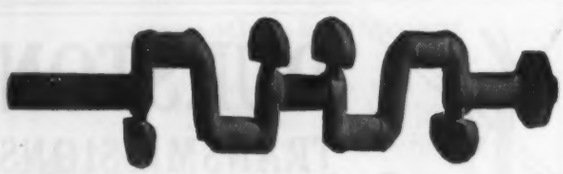

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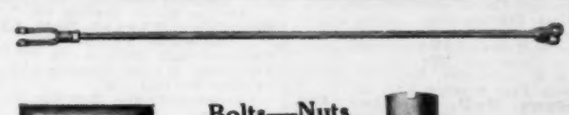

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Automotive
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Staynew Filter Corporation

Alloys, Alumino-Vanadium
Vanadium Corporation of America

Alloys, Cupro-Vanadium
Vanadium Corporation of America

Alloys, Ferro-Molybdenum
Vanadium Corporation of America

Alloys, Ferro-Tungsten
Vanadium Corporation of America

Alloys, Ferro-Vanadium
Vanadium Corporation of America

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*Sterling Mfg. Co.
Westinghouse Electric & Mfg. Co.

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Westinghouse Electric & Mfg. Co.

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Babbitt, D103
*Federal-Mogul Corporation
*Light Mfg. & Foundry Co.

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Williams & Co., J. H.

Bars, Bronze
Bunting Brass & Bronze Co.
Mueller

Batteries, Farm Lighting
Willard Storage Battery Co.

Batteries, Storage, Lighting, B23
*Prest-O-Lite Co.
*Westinghouse Union Battery Co.
*Willard Storage Battery Co.

Batteries, Storage, Starting and Lighting, B23
*Prest-O-Lite Co.
*Westinghouse Union Battery Co.
*Willard Storage Battery Co.

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Bunting Brass & Bronze Co.
Doehler Die-Casting Co.

Bearings, Babbitt and Bronze
Bunting Brass & Bronze Co.
Doehler Die-Casting Co.
Federal-Mogul Corporation
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Stewart Mfg. Corporation

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*Gurney Ball Bearing Co.
*Marlin-Rockwell Corporation
*New Departure Mfg. Co.
*S K F Industries, Inc.
*Strom Ball Bearing Mfg. Co.

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*Gurney Ball Bearing Co.
*Marlin-Rockwell Corporation
*S K F Industries, Inc.
*Strom Ball Bearing Mfg. Co.

Bearings, Ball, Annular, Extra Small Series, C33
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*New Departure Mfg. Co.
*Norma-Hoffmann Bearings Corporation
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*Federal Bearings Co., Inc.
*Gurney Ball Bearing Co.
*Marlin-Rockwell Corporation
*New Departure Mfg. Co.
*Norma-Hoffmann Bearings Corporation
*S K F Industries, Inc.
*Strom Ball Bearing Mfg. Co.
Torrington Co.

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*New Departure Mfg. Co.
*Norma-Hoffmann Bearings Corporation
*S K F Industries, Inc.

Bearings, Ball, Annular, Wide Type, C31
*Brown-Lipe Gear Co.
*Fafnir Bearing Co.
*New Departure Mfg. Co.
*S K F Industries, Inc.
*Strom Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Single-Direction, Flat-Face Type, C35 and C36
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma-Hoffmann Bearings Corporation
*Strom Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Single-Direction, Self-Aligning Type, C37 and C38
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma-Hoffmann Bearings Corporation
*S K F Industries, Inc.
*Strom Ball Bearing Mfg. Co.

Bearings, Ball, Thrust, Steering Knuckle Type, C34
*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma-Hoffmann Bearings Corporation
*Strom Ball Bearing Mfg. Co.

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*Bock Bearing Co.
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*Norma-Hoffmann Bearings Corporation

Bearings, Roller, Tapered, Inch-Type
Timken Roller Bearing Co.

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*Bantam Ball Bearing Co.
*Bearings Co. of America
*Fafnir Bearing Co.
*Norma-Hoffmann Bearings Corporation

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Timken Roller Bearing Co.

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*Goodyear Tire & Rubber Co., Inc.
*Russell Mfg. Co.

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*Gilmer Co., L. H.
*Goodyear Tire & Rubber Co., Inc.

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*Gilmer Co., L. H.
*Goodyear Tire & Rubber Co., Inc.
*Russell Mfg. Co.

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Central Steel Co.
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Park Drop Forge Co.
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*National Acme Co.
*Steel Products Co.

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Steel Products Co.

Bolts, Spring-Center, H4
*National Acme Co.

Bolts, Spring Shackle
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Carbureters, A8
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Milwaukee Die Casting Co.
Mueller
*Scovill Mfg. Co.
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Bakelite Corporation

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Controls, Brake
Perrot Brake Corporation

Controls, Transmission
Brown-Lipe Gear Co.

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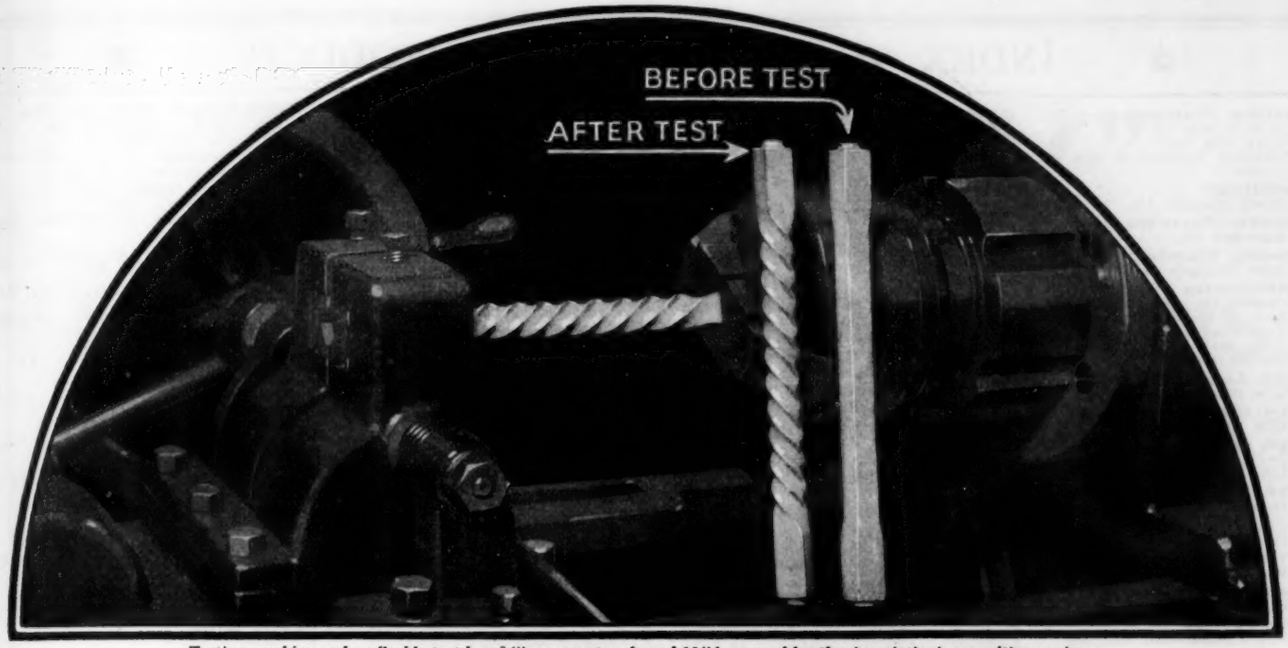
EXPLANATION OF SYMBOLS

Parts and materials followed by key numbers have been standardized by the S. A. E. The numbers refer to S. A. E. HANDBOOK data sheets on which each standard is published.

*Companies whose names are preceded by an asterisk supply the parts or materials under which the company is listed as conforming with the S. A. E. Standard referred to.

**Parts and materials followed by two asterisks indicate that two or more S. A. E. Standards are applicable. Information as to standards incorporated should be obtained from the manufacturer.

The addresses of companies listed in this index can be obtained from their current advertisements indexed on page 92.



Testing machine and malleable test bar ¾" square at ends and 11" long used by the Association's consulting engineer to make torsion tests on the product of member companies.

Certificate Holders for the Quarter Ending September 30th, 1924

Albany Malleable Iron Co.	Voorheesville, N. Y.
Albion Malleable Iron Co.	Albion, Mich.
American Malleable Castings Co.	Marion, O.
American Malleables Co.	Lancaster, N. Y., and Owosso, Mich.
Badger Malleable & Mfg. Co.	South Milwaukee, Wis.
Baltimore Malleable Iron & Steel Casting Co.	Baltimore, Md.
Belle City Malleable Iron Co.	Racine, Wis.
Chain Belt Co.	Milwaukee, Wis.
Chicago Malleable Castings Co.	West Pullman, Chicago, Ill.
Columbia Malleable Castings Co.	Columbia, Pa.
Columbus Malleable Iron Co., The	Columbus, O.
Danville Malleable Iron Co.	Danville, Ill.
Dayton Malleable Iron Co.	Dayton, O., Ironton, O., and Canton, O.
Decatur Malleable Iron Co.	Decatur, Ill.
Devlin Mfg. Co., Thomas	Philadelphia, Pa.
Eastern Malleable Iron Co., The	Naugatuck Malleable Iron Works, Naugatuck, Conn.; Bridgeport Malleable Iron Works, Bridgeport, Conn.; Troy Malleable Iron Works, Troy, N. Y.; Wilmington Malleable Iron Works, Wilmington, Del.; Vulcan Iron Works, New Britain, Conn.
Erie Malleable Iron Co.	Erie, Pa.
Federal Malleable Co.	West Allis, Wis.
Fort Pitt Malleable Iron Co.	Pittsburgh, Pa.
Frazer & Jones Co.	Syracuse, N. Y.
General Electric Co.	Erie, Pa.
Glancy Malleable Corporation	Waukesha, Wis.
Illinois Malleable Iron Co.	Chicago, Ill.
Iowa Malleable Iron Co.	Fairfield, Ia.
Kalamazoo Malleable Iron Co.	Kalamazoo, Mich.
Laconia Car Co.	Laconia, N. H.
Lakeside Malleable Castings Co.	Racine, Wis.
Lancaster Foundry Co.	Lancaster, Pa.
Link-Belt Co.	Indianapolis, Ind.
Marion Malleable Iron Works	Marion, Ind.
Moline Malleable Iron Co.	St. Charles, Ill.
National Malleable & Steel Castings Co.,	Rockford, Ill.
Cleveland, O., Chicago, Ill., Indianapolis, Ind., Toledo, O., E. St. Louis, Ill.	
Northern Malleable Iron Co.	St. Paul, Minn.
Northwestern Malleable Iron Co.	Milwaukee, Wis.
Peoria Malleable Castings Co.	Peoria, Ill.
Pittsburgh Malleable Iron Co.	Pittsburgh, Pa.
Rhode Island Malleable Iron Works	Hillsgrove, R. I.
Rockford Malleable Iron Works	Rockford, Ill.
Ross-Meehan Foundries, The	Chattanooga, Tenn.
St. Louis Malleable Casting Co.	St. Louis, Mo.
Saginaw Malleable Iron Co.	Saginaw, Mich.
Standard Malleable Castings Co.	Terre Haute, Ind.
Stowell Co., The	South Milwaukee, Wis.
Superior Steel Castings Co.	Benton Harbor, Mich.
Symington Co., T. H., The	Rochester, N. Y.
Temple Malleable Iron & Steel Co.	Temple, Pa.
Terre Haute Malleable & Mfg. Co.	Terre Haute, Ind.
Trenton Malleable Iron Co., The	Trenton, N. J.
Union Malleable Iron Co., The	E. Moline, Ill.
Vermilion Malleable Iron Co.	Hoopeston, Ill.
Wanner Malleable Castings Co.	Hammond, Ind., and Beloit, Wis.
Warren Tool & Forge Co.	Warren, O.
Webster Mfg. Co., The	Chicago, Ill.
Wisconsin Malleable Iron Co.	Milwaukee, Wis.
York Mfg. Co.	York, Pa.
Zanesville Malleable Co.	Zanesville, O.

Constant Testing to Uphold the Quality of Certified Malleable

No. 1—Torsion Tests

This is an actual photograph of torsion test being made on malleable test bars submitted regularly by member companies to the association's consulting engineer.

The usual conception of a casting is one of brittleness and really few people realize that high grade malleable iron produced by companies listed on this page will uniformly stand such treatment as this test indicates.

The bars in this picture have been twisted at lathe speed through three complete turns or 1080 degrees with no indication of fracture. During the annealing process, malleable iron gives up its brittle characteristics and develops unusual mechanical properties such as ductility, great strength, toughness and easy machining qualities.

Certified Malleable Iron is the product of those plants who receive a quarterly certificate of merit from the consulting engineer of The American Malleable Castings Association; certifying that their product has met his exacting physical tests and that their plant practice, as shown by rigid inspection, insures the production of uniform malleables of the highest quality and integrity.

AMERICAN MALLEABLE CASTINGS ASSOCIATION
UNION TRUST BUILDING CLEVELAND, OHIO

POSITIVE PHYSICAL PROPERTIES — AcA CERTIFIED TRADE MARK

CERTIFIED-MALLEABLE CASTINGS

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Link-Belt Co.

Cranks, Starting
Steel Products Co.

Crankshafts
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Wyman-Gordon Co.

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Cups, Oil
Gits Bros. Mfg. Co.

Cups, Oil and Grease, C57
*Bowen Products Corporation
*Link-Belt Co.

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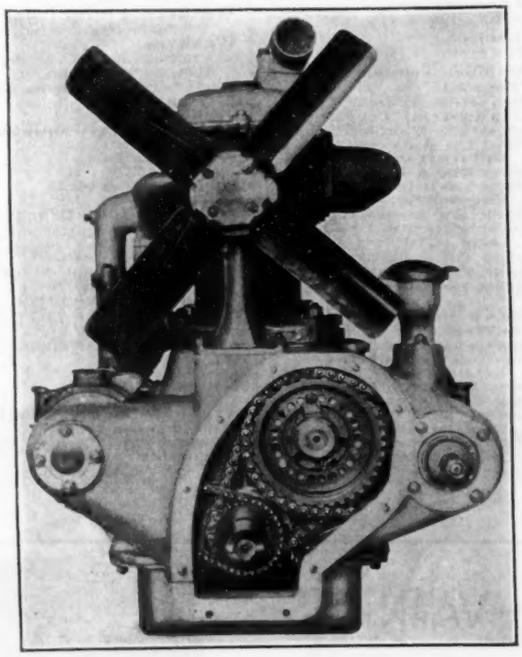
SILENT HIGH MILEAGE CHAINS

ENGINEERS KNOW

—that dependability, long life and uniform performance are requisites for any front end drive chain.



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Severe duty is an important factor and "WHITNEY SILENT HIGH MILEAGE CHAINS" are more durable and frequently outlast the life of the car.

BECAUSE

"WHITNEY SILENT HIGH MILEAGE CHAINS" are dependable and uniform, and have made an unrivalled record for high "average service."

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Are comparatively rapid and inexpensive.
Do not mar finished surfaces.
Do not strain and start fractures in metal.
The only instrument that can be applied to dead soft metals and intensely hard steel.
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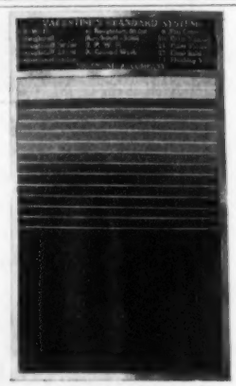

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Prior to any other balloon experiments even, Motor Wheel actual experience on this subject had mounted into many thousands of miles.

Naturally Motor Wheel had an intimate part in the first commercial use of balloon tires,* because wheels by Motor Wheel made those balloon tires practicable.

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On Yellow Cabs, equipped with Disteel Wheels

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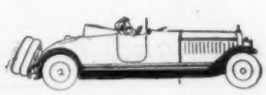

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CAN you shift your gears easily at zero and below? You ought to; if you can't you haven't the right lubricant in your transmission.

People take almost anything for transmission and differential lubrication. If starting is hard, and gear shifting harder, they add light oil to lessen the strain on their muscle and the battery. This does no permanent good.

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At zero and well below it flows freely and allows easy gear shift.

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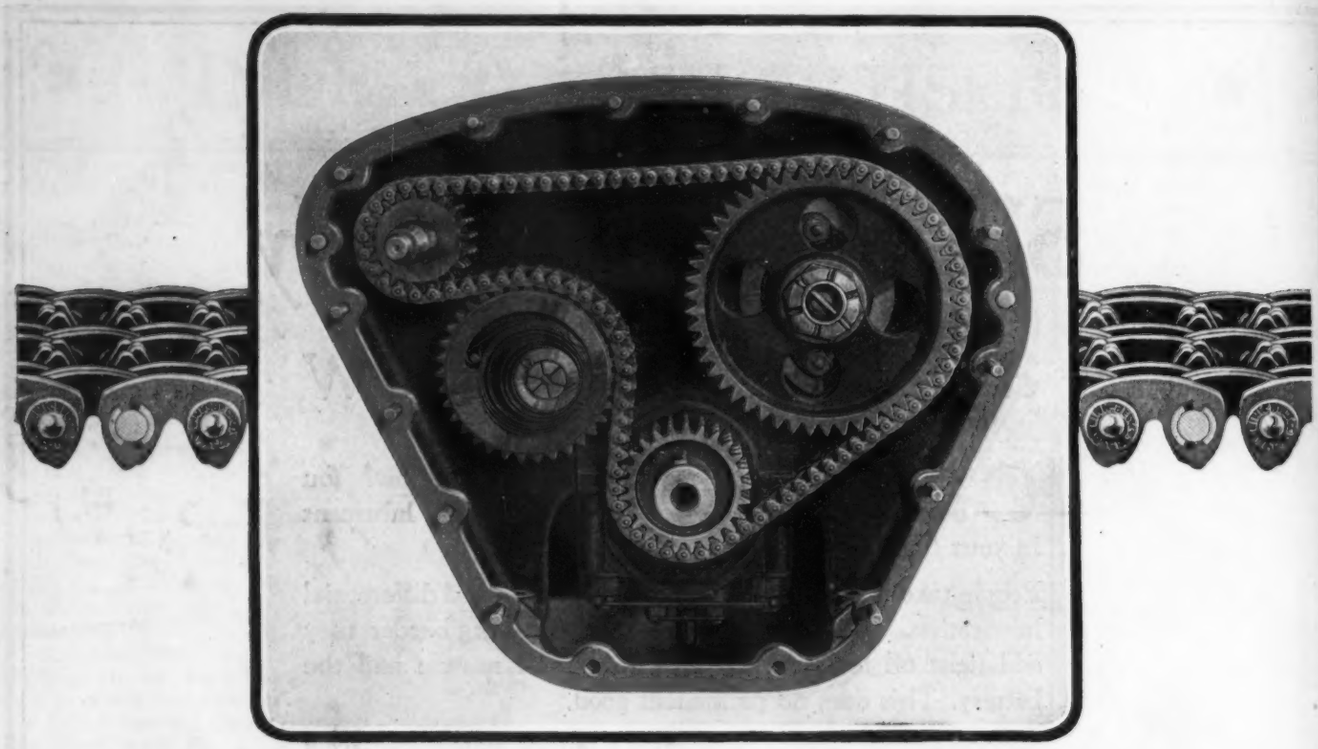

An Ever-growing Family

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Isotta Fraschini, Type 8A,
Rickenbacker Vertical Eight,
Elcar, Eight-in-Line,
Auburn, Eight-in-Line—

are the most recent to adopt the Link-Belt Silent Chain "Front-End" Drive. Pierce-Arrow, Isotta Fraschini, Elcar, and Auburn use the Link-Belt Automatic Chain Adjustment.

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Let our experienced engineers work with yours in securing a quiet motor.

LINK-BELT COMPANY, INDIANAPOLIS

1915

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